201-16041A

U.S. High Production Volume (HPV) Chemical Challenge Program

CATEGORY DEVELOPMENT AND JUSTIFICATION, AND PROPOSED TEST PLAN FOR COBALT STEARATE AND FATTY ACIDS, TALL OIL, COBALT SALTS

Prepared by

MorningStar Consulting, Inc.

on behalf of

The Metal Carboxylates Coalition

A SOCMA Affiliated Consortium

Specifically Sponsored By

OM Group, Inc.
Shepard Chemical Co.

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SUMMARY

Cobalt Stearate and Fatty acids, Tall Oil, Cobalt Salts are two sponsored chemicals organized under the Metal Carboxylates Coalition (The Coalition), an HPV testing consortium managed by the Synthetic Organic Chemical Manufacturers Association's (SOCMA) VISIONS Department. The Coalition member companies sponsoring these compounds are OM Group (OMG) and The Shepherd Chemical Company.

The Metal Carboxylates Coalition has sponsored 19 compounds that are metal salts of carboxylic acids (metal carboxylates). These compounds readily dissociate to the corresponding metal and carboxylic acid. The HPV endpoints are fulfilled using a combination of data from the parent molecule, as well as for the dissociation products; that is, a metal salt and/or a carboxylic acid. Selected testing of the parent molecules has been proposed to further fulfill HPV endpoints. Robust summaries are provided for the parent molecules as well as the dissociation products.

This submittal provides the information for:

Cobalt Stearate	CASRN 13586-84-0
Fatty acids, Tall Oil, Cobalt Salts	CASRN 61789-52-4

The proposed testing is presented in the attached Test Plan matrix (Table 6)

1.0 BACKGROUND

This submittal provides the information for:

Cobalt Stearate	CASRN 13586-84-0
Fatty Acids, Tall Oil, Cobalt Salts	CASRN 61789-52-4

Cobalt stearate is the cobalt salt of stearic acid. Because cobalt is divalent, two stearic acid molecules are involved. The structural formula is $Co(C_{18}H_{35}O_2)_2$. The cobalt salts of fatty acids, tall oil are more difficult to characterize chemically because the tall oil fatty acids are derived from the fractional distillation of crude tall oil, which is a by-product from the pulping of pine trees. The mixture of fatty acids in pine trees varies by species and even within species (Pine Chemicals Association, 2004). The composition of a typical tall oil fatty acid includes oleic acid (48%), linoleic acid (35%), conjugated linoleic acid (7%), stearic acid (2%), palmitic acid (1%), and other acids and unsaponifiable matter (Pine Chemicals Association, 2004). Oleic acid and linoleic acid, like stearic acid, are C18 fatty acids with slightly differing degrees of saturation.

Cobalt stearate and fatty acids, tall oil, cobalt salts are high molecular weight compounds. The molecular weight for cobalt stearate is 625.9. The molecular weight of fatty acids, tall oil, cobalt salt is undefined due to the undefined nature of the acid component; however, the typical composition would be largely oleic and linoleic acid, both of which are C18 unbranched aliphatic acids, as is stearic acid. Thus the molecular weight of fatty acids, tall oil, cobalt salts would be similar to that of cobalt stearate.

Figure 1 provides the structure of cobalt stearate. Figure 2 provides the structures of oleic acid and linoleic acid, major components of fatty acids, tall oil. The cobalt salts of fatty acids, tall oil consist of cobalt associated with the various acid moieties, similar to cobalt stearate.

1.1 Use Patterns for Metal Carboxylates

The metal carboxylates function to deliver a metal ion into chemical reactions. The carboxylic acids (acids) are tailored for use in different products or chemical reactions.

In general the cobalt carboxylates are used as oxidative polymerization catalysts in many product areas. These areas include, but are not limited to: ink and paint driers; unsaturated polyester resins, and hydrodesulfurization in their manufacturing; and the making of the insecticide DEET (diethyltoluamide). Some of these carboxylate compounds are used in oxygen scavenger plastics as well (for example, plastic bottles). The tire industry also uses cobalt carboxylate compounds as adhesion promoters in tire manufacturing. These compounds facilitate adhesion between the rubber in the steel cords. The metal (not salt) loadings range from 0.01 – 0.5% depending upon the application.

1.2 Common Characteristics of Metal Carboxylates

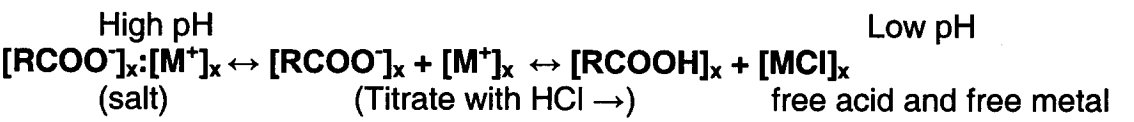
These two metal carboxylates (cobalt stearate and fatty acids, tall oil, cobalt salts) are functionally similar and have the same ionizable substituents, the same metal cation, and a structurally similar carboxylic acid group (RCOOH). These compounds are divalent compounds and have two carboxylic acid moieties per molecule. The metal carboxylate salts are designed to add metals to chemical reactions; therefore, they are designed to readily dissociate into the free metal and free acid.

2.0 Dissociation Studies

One key characteristic of metal carboxylates is that they readily dissociate from an ion pair into free metal and free acid. They are found as partially dissociated products in the ambient environment (i.e., neutral pH). Dissociation is a reversible process and the proportion of dissociated salt present is dependent on the pH and pKa (the dissociation constant), which is the pH at which 50% dissociation occurs. In the low pH environment of the digestive tract (e.g., pH 1.2) complete dissociation will occur for these metal carboxylates. The transport and bioavailability of the metals and acids are determined by their solubility in environmental media and biological fluids which is determined by environmental parameters such as pH.

The Metal Carboxylates Coalition conducted studies to determine the dissociation constants of each of these compounds. The mean pKa value for cobalt stearate was 7.5 at 20ºC while the mean pKa value for fatty acids, tall oil, cobalt salts was 5.82. These results indicate that significant dissociation will occur at approximately neutral pH (i.e., representative of aquatic and marine ecosystems), while complete dissociation will occur at physiologically relevant pH of the mammalian stomach (pH 1.2). These findings are particularly important in relating available data for the respective acids and metals to support the existing data for cobalt stearate and fatty acids, tall oil, cobalt salts in the fulfillment of critical endpoints.

Dissociation is a reversible reaction, splitting the parent compound into two or more chemical species which may be ionic, but are not necessarily so. The process can be generally represented as:



The pKa and pH are equal when the metal carboxylate salt is 50% dissociated. The parent compounds, the metal carboxylate salts, are associated ionized molecules.

The dissociation constant is important for two reasons. First, it determines the proportion of any specific acid or metal that is dissociated at a given pH. The free acid and corresponding free metal are often much different than the salt (ion pair) moiety in characteristics such as solubility, adsorption, and toxicity. The proportion of dissociation influences the behavior of the substance in the environment and bioavailability of the acid and metal constituents of metal carboxylate salts.

The dissociation constants for 18 related metal carboxylate compounds tested have pKa (pKb) values (pKa1) in the neutral range (5.088 to 8.448). This indicates that in the neutral pH range, significant portions of the metal carboxylates will be dissociated. In addition, at the low pH of the mammalian stomach (pH 1.2) all of the metal carboxylates would be expected to be completely or nearly completely dissociated. This indicates that the absorption and any observed toxicity would be independent for the respective acid and metal when administered orally.

The dissociation constants show that at the pH of the stomach and at the pH of environmental media, the important moieties are the ionized free acid and metal. Because of this, environmental fate, ecotoxicity, and mammalian toxicity of the free acid, or that for a simple salt which would readily dissociate (e.g., the sodium salt), can serve as surrogate data for the acid component of respective metal carboxylates. Similarly, under these conditions, data for the metal ion can be represented by fate and toxicity data on free metal ion or simple metal salts (e.g., metal chlorides). Therefore, the role in any observed toxicity for acids and metals can be evaluated independently (i.e., as the free metal and/or free acid).

3.0 Bioequivalency

The work described below by Stopford et al. (unpublished)[1] shows that cobalt chloride is similar to, or more bioavailable than, the corresponding cobalt carboxylate salts, which makes the chloride a conservative surrogate in estimating bioavailability and toxicity of dissociated metal. Cobalt chloride has thus been emphasized during preparation of the attached robust summaries and provides the preferred surrogate data for cobalt carboxylate salts.

The recent studies by Stopford et al. to evaluate the "bioequivalency" (an estimate of bioavailability) of cobalt compounds included three cobalt carboxylates and cobalt chloride. The solubility of these compounds in synthetic

[1] Stopford, W., J. Turner, D. Cappellini, and T. Brock. (unpublished) Bioequivalency Testing of Cobalt Compounds (Oct 15, 2002 Draft). Conducted by Duke University Medical Center, Division of Occupational and Environmental Medicine for the Cobalt Development Institute, Research Triangle Park, N.C.

biological fluids (gastric juices, intestinal juices, several interstitial fluids, and cytosol) showed that these salts were completely dissociated and dissolved at gastric pH and cytosolic pH. The dissolution of these compounds ranged from 26.1% to 80.4 % of available cobalt at neutral pH (Table 1). The results for cobalt chloride and cobalt 2-ethyl-hexanoate were very similar at acidic and neutral pH. Cobalt neodecanoate and cobalt naphthenate showed similar levels of dissolution at acidic (gastric and cytosolic) pH, but smaller proportions of the metal component of these compounds were dissolved at neutral pH. The differences in dissolution for these metal carboxylates at neutral pH in synthetic body fluids could be related to differences in their dissociation constants.

These data are valuable in understanding cobalt stearate and fatty acid, tall oil, cobalt salts for three reasons:

1. They confirm the prediction that these compounds would be expected to be completely dissociated in the gastrointestinal tract (low pH) and a substantial proportion would be expected to be dissociated and bioavailable at neutral pH (7.4).

2. The fraction of the three cobalt carboxylates evaluated by Stopford et al. that was dissolved at acidic and neutral pH was very similar for different acid constituents with a range of molecular weights and chain lengths. This finding greatly strengthens the extrapolation of the results to cobalt stearate and fatty acids, tall oil, cobalt salts.

3. The work by Stopford et al. shows that cobalt chloride is similar to, or more bioavailable than, the corresponding cobalt carboxylate salts, which makes the chloride a conservative surrogate in estimating bioavailability and toxicity of dissociated metals. Cobalt chloride has been emphasized during preparation of the attached robust summaries and provides the preferred surrogate data for the cobalt carboxylate salts.

Work by Firriolo[2] demonstrated that absorption, distribution, and excretion of cobalt from cobalt carboxylic acids is independent of the acid. This work was based on cobalt chloride and cobalt naphthenate and confirms observations by Stopford et al. that dissociation of the carboxylate is complete at the pH of the stomach.

[2] Firriolo, J.M. 1992. Disposition and toxicity after oral and intravenous administration of cobalt naphthenate and cobalt chloride in rats. Ph.D. Dissertation, University of Arizona.

4.0 Supporting Data for HPV Chemicals and their Dissociation Products

Data for cobalt stearate (Appendix A) and fatty acids, tall oil, cobalt salts (Appendix B) and their dissociation products (cobalt chloride, stearic acid, and fatty acids, tall oil [Appendixes C, D, and E, respectively]) are provided in robust summary format.

Consistent with discussions between the Metal Carboxylates Coalition and the EPA, data for the dissociation products (metals and acids) are recognized as being essential to understanding the environmental fate and toxicological characteristics of the respective metal carboxylate salts. Data for stearic acid, fatty acids, tall oil, and cobalt are useful in characterizing the hazard of the cobalt stearate and fatty acids, tall oil, cobalt salts.

In summary, the key points relative to these two HPV chemicals are:

- Dissociation to the carboxylic acids and cobalt (described as cobalt chloride);
- Dissociation constants (pKa) in the circum neutral range (5.82 to 7.5);
- Complete or nearly complete dissociation at gastric and cytosolic pH levels;
- A moderate to high proportion of dissociation in the neutral pH range;
- General bioequivalency for salts with the same metal cation (e.g., cobalt) and different acids or the chloride salt;
- Cobalt carboxylates have the same use pattern, to provide free metal ion to chemical reactions.
- Existing data for the parent molecule or both of its dissociation products will be sufficient to address specific endpoints.

5.0 Proposed Test Plan

The Metal Carboxylates Coalition has relied on the fact that these compounds will dissociate and that the respective acid (stearic acid or fatty acids, tall oil), and metal (cobalt) are the chemicals of interest. Studies conducted by the Metals Carboxylates Coalition have demonstrated that dissociation of these materials will occur readily in water at neutral pH's and completely at the pH of the stomach (pH 1.2). This is consistent with data for other metal carboxylates.

The Metal Carboxylates Coalition is relying on the data for cobalt and for stearic acid to support cobalt stearate and to minimize unnecessary testing. A robust summary document has been prepared for cobalt chloride, which describes the necessary endpoint data under the HPV Program (Appendix C). A robust summary document has also been prepared for stearic acid (Appendix D).

Stearic acid has a long history of safe use in foods and cosmetics. This compound is sponsored within the Aliphatic Acids Category under the HPV Challenge Program. More complete or more robust data may become available following the Aliphatic Acids Category submission to the EPA by The Soap and Detergent Association. If needed, the Metal Carboxylates Coalition will then revise the current robust summary document to include more complete stearic acid data and will make a supplemental submission.

To support fatty acids, tall oil, cobalt salts, the Metal Carboxylates Coalition is relying on the data for cobalt and for fatty acids, tall oil. As mentioned previously, the robust summary document prepared for cobalt chloride is attached as Appendix C. Fatty acids, tall oil is sponsored by the Pine Chemicals Association, Inc. as part of the category Tall Oil Fatty Acids and Related Substances. The robust summaries for fatty acids, tall oil submitted to EPA as part of the final submission from the Pine Chemicals Association, dated August 2004, are included as Appendix E. Also included in Appendix E is the IUCLID dataset for fatty acids, tall oil, dated February 2000.

Tables 2 - 5 provide a summary of the data for cobalt stearate and fatty acids, tall oil, cobalt salts, as well as their dissociation products

Physicochemical Properties

The physicochemical properties are summarized in Table 2. The Metal Carboxylates Coalition conducted GLP studies to determine several properties of cobalt stearate and fatty acids, tall oil, cobalt salts, including melting point, boiling point, water solubility and dissociation constant. Melting point studies were performed to generate data for both HPV compounds (see Table 2). In studies conducted to determine the boiling points, cobalt stearate decomposed before boiling could occur and a boiling point was not observed for fatty acids, tall oil, cobalt salts. Based upon the properties of the respective acids, the vapor pressure of the two HPV compounds is expected to be low. Studies indicated the water solubility of the two compounds was fairly low, but greater than their respective acids. This result may be related to the procedure used, which quantified the amount of test compound in solution by measuring the amount of cobalt. Since cobalt stearate and fatty acids, tall oil, cobalt salts dissociate, the water solubility test results may reflect dissociation rather than solubility per se. The octanol-water partition coefficient (Kow) is a property that is determined on unionized, undissociated chemicals and therefore is not an appropriate property to measure for metal carboxylates. The Kow of the respective acids provides surrogate data to estimate this property for the dissociated cobalt stearate and fatty acids, tall oil, cobalt salts.

No additional physical chemical properties testing is necessary or proposed.

Environmental Fate

Table 3 provides a summary of the available environmental fate data for the two HPV chemicals, as well as their dissociation products. The Metal Carboxylates Coalition conducted studies to determine the dissociation constants of cobalt stearate and fatty acids, tall oil, cobalt salts; the resulting pKa values were 7.50 and 5.82, respectively. These results indicate that the environmental fate characteristics of these chemicals will be dependent upon the characteristics of their dissociation products, data for which are presented in Table 3. The dissociated cobalt metal, of course, will not photodegrade or biodegrade. The respective acids, however, are amenable to these degradation processes. Predictions based upon structure-activity models (e.g., EPIWIN) indicate that stearic acid is photodegradable and would tend to be found in the sediment or soil compartments of the environment. Several laboratory studies indicate that both stearic acid and fatty acids, tall oil are readily biodegradable. Predictions for photodegradation and transport (fugacity) have been calculated using EPIWIN for oleic acid and linoleic acid, the two major components of a typical fatty acid, tall oil. These results are similar to those for stearic acid.

A biodegradation study with cobalt stearate is proposed. Biodegradation data will show that the rate of degradation for the cobalt stearate salt is the same as stearate alone and that the cobalt does not inhibit biodegradation of the stearate. Both cobalt stearate and fatty acids, tall oil, cobalt salts would have the same combined effect on biodegradation; therefore only one study with cobalt stearate is proposed.

Environmental Effects

Table 4 provides a summary of the available environmental effects data for cobalt stearate, and fatty acids, tall oil, cobalt salts, as well as their dissociation products. No information is available for the two HPV chemicals. For the dissociation products, adequate data exist to characterize the aquatic toxicity of cobalt. Studies have been conducted to determine the acute toxicity of fatty acids, tall oil to fish, invertebrates and algae, providing sufficient information for these endpoints. However, for stearic acid, only data on toxicity to fish are available, and this is for a study of time to lethality (LT50 endpoint), so it is marginally useful. It is anticipated that additional aquatic toxicity data for stearic acid will be generated by the Aliphatic Acids Consortium. When available, the Metal Carboxylates Coalition will amend this test plan with these data. To demonstrate that dissociation product data is representative of the aquatic toxicity for the two HPV chemicals, it is proposed that acute toxicity studies for fish, daphnia and algae be conducted with cobalt stearate.

Acute toxicity studies with fish, daphnia and algae are proposed to characterize the aquatic toxicity of cobalt stearate. In addition, an acute daphnia study with

fatty acids, tall oil, cobalt salts is proposed as a bridging study to demonstrate that the dissociation product data are representative for this metal carboxylate salt..

Human Health Effects

Data elements for human health effects endpoints were examined for cobalt stearate and fatty acids, tall oil, cobalt salts, and their dissociation products (Table 5). Mammalian toxicity will be represented by data available for the salt where available (e.g., Acute Oral LD50) and dissociation products. For cobalt chloride, several studies are available to document acute oral toxicity and repeated dose toxicity. Male reproductive effects have been demonstrated in rats and mice and developmental toxicity studies exist for both rats and mice. Cobalt (II) is generally not mutagenic in bacterial assays but has genotoxic effects in mammalian systems. For fatty acids, tall oil, data are available for acute oral toxicity, repeated dose toxicity, and reproductive/developmental toxicity. In addition, tests have demonstrated that fatty acids, tall oil was not mutagenic in bacterial assays but was clastogenic to mammalian cells (though at cytotoxic concentrations).

All endpoints are filled for cobalt chloride and fatty acids, tall oil. Data gaps exist for stearic acid. However, the Coalition will supplement this Test Plan with data being generated by the Aliphatic Acids Consortium on stearic acid, when these studies become available.

An oral LD50 study is proposed for fatty acids, tall oil, cobalt salts as part of establishing the category approach, i.e., that the dissociation products can be used to predict the toxicity of the salts. An OECD 422 study with cobalt stearate is proposed as a bridging study to show that dissociation product data is representative of the mammalian toxicity for these two metal carboxylate salts. Because there is no data available on the genetic toxicity of stearic acid to mammalian systems, a chromosomal aberration study is proposed for cobalt stearate. A chromosomal aberration study is also proposed for fatty acids, tall oil, cobalt salts based on reported clastogenicity of both dissociation products (cobalt and fatty acids, tall oil).

5.1 TEST PLAN SUMMARY

Table 6 provides the test plan for cobalt stearate and fatty acids, tall oil, cobalt salts. A biodegradation study is proposed for cobalt stearate. For ecotoxicity, acute testing with fish, daphnia, and algae are also proposed with cobalt stearate. An oral acute LD50 test, a combined Repeated Dose w/Repro/Developmental Screen (OECD 422) and a chromosomal aberration test are also proposed with cobalt stearate. For fatty acids, tall oil, cobalt salts, an acute daphnia test, an acute oral LD50 test, and a chromosomal aberration test are proposed.

FIGURES

Figure 1: Cobalt Stearate

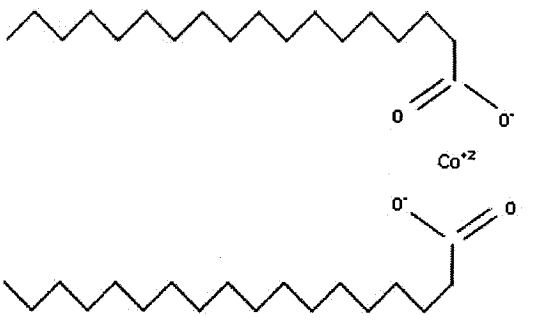
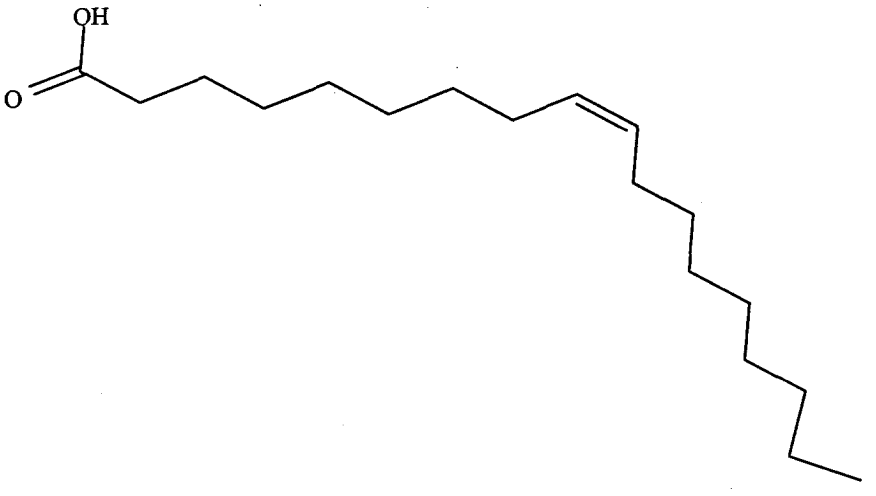
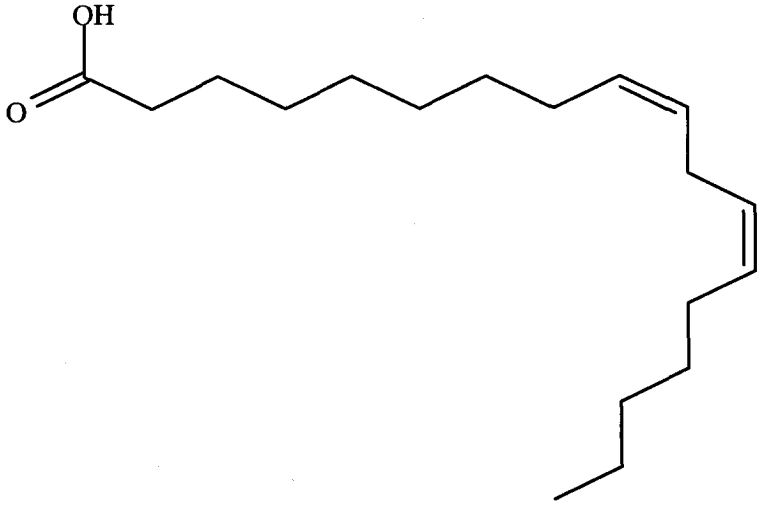


Figure 2: Fatty acids, tall oil: typical major components

Oleic acid
$C_{18}H_{34}O_2$



Linoleic acid
$C_{18}H_{32}O_2$



TABLES

Table 1. Results of Extraction of Cobalt from Surrogate Biological Fluids

Matrix (pH)	Maximum Solubility (% of available metal)			
	$CoCl_2$	Co 2-ethyl-hexanoate	Co naphthenate	Co neodecanoate
Gastric pH (1.5)	>91.6	100	>85.7	100
Intestinal pH (7.4)	>79.4	50.8*	45.4*	30.8*
Alveolar pH (7.4)	>68	>59.6	35.4*	26.1*
Interstitial pH (7.4)	78.4	>80.4	40*	43.1*
Serum	>85	>66.9	42.9*	46.6*
Intracellular pH (4.5)	>89.6	100	>79.1	>78.1

* maximum extraction level at 72 hours

All data is taken from Stopford et al. (unpublished) Bioequivalency Testing of Cobalt Compounds. Conducted by Duke University Medical Center, Division of Occupational and Environmental Medicine for the Cobalt Development Institute.

Table 2. Summary of Available and Relevant Physical/Chemical Properties Data for Cobalt Stearate, Fatty Acids, Tall Oil, Cobalt Salts, and their Dissociation Products

Compound	Physical/Chemical Properties				
	Melting Point (deg C)	Boiling Point (deg C)	Vapor Pressure (hPa)	Partition coefficient (log Kow)	Water Solubility (mg/L)
Dissociation Product: Cobalt chloride	735	1,049	NA	NA	450,000
Cobalt stearate	45.1 – 79.3	ND	-	NA	6.4 @ 20ºC
Dissociation Product: Stearic acid	69 - 70	383	1.33 @173.7	8.42	0.568 @ 25ºC
Fatty acids, tall oil, cobalt salts	-38 to -39	ND	-	NA	149 @ 20ºC
Dissociation Product: Fatty acids, tall oil	NA	160 - 210 @ 6.6 hPa	negligible	4.4 – 8.3 @ pH 2; 3.6 – 7.4 @ pH 7.5	12.6

ND = no data; testing did not yield results for boiling point
NA = not applicable due to substance properties

Table 3: Summary of Available and Relevant Environmental Fate Data for Cobalt Stearate, Fatty Acids, Tall Oil, Cobalt Salts, and their Dissociation Products

Compound	Environmental Fate			
	Stability in Water	Photo-degradation	Level III Fugacity Model	Biodegradation
Dissociation Product: Cobalt chloride	(high water solubility)	NA	NA	NA
Cobalt stearate	Dissociates: pKa = 7.50 @ 20ºC	-	-	-
Dissociation Product: Stearic acid	(low water solubility)	T ½ = 0.5 days	Air: 0.676 Water: 7.19 Soil: 28.9 Sediment: 63.3	Readily biodegradable
Fatty acids, tall oil, cobalt salts	Dissociates: pKa = 5.82 @ 20ºC	-	-	-
Dissociation Product: Fatty acids, tall oil [(1)]	(low water solubility)	T ½ = 2 hours or less	Air: <0.1 Water: 7-8 Soil: 28-29 Sediment: 63-64	Readily biodegradable

NA = not applicable due to substance properties

[(1)] Photodegradation and fugacity results are averages of modeled results for oleic acid and linoleic acid, two components of fatty acids, tall oil

Table 4. Summary of Available and Relevant Environmental Effects Data for Cobalt Stearate, Fatty Acids, Tall Oil, Cobalt Salts, and their Dissociation Products

Compound	Environmental Effects		
	Acute Toxicity to Fish (mg/L)	Acute Toxicity to Daphnia (mg/L)	Acute Toxicity to Algae (mg/L)
Dissociation Product: Cobalt chloride	1.41 – 333 (96-h LC50)	1.52 – 5.5 (48-h EC50)	0.52 (96-h EC50)
Cobalt stearate	-	-	-
Dissociation Product: Stearic acid	LT50 data (marginally useful)	-	-
Fatty acids, tall oil, cobalt salts	-	-	-
Dissociation Product: Fatty acids, tall oil	10 (96-h LC50) to > 1000 (96-h LL50)	55.7 (48-h EC50) to > 1000 (48-h LL50)	0.79 – 9 (EC50) to 854 (72-h EL50)

Table 5. Summary of Available and Relevant Human Health Effects Data for Cobalt Stearate, Fatty Acids, Tall Oil, Cobalt Salts, and their Dissociation Products

Compound	Human Health Effects				
	Acute Toxicity (mg/kg)	Repeat Dose Toxicity	Reproductive Effects	Developmental Effects	Genetic Toxicity
Dissociation product: Cobalt chloride	LD50 = 42.4 – 190 (rat) LD50 = 89.3 (mouse)	NOAEL = 0.6 mg Co/kg; LOAELs 0.5 – 30.2 mg Co/kg/day	Effects in rats at 13.2 – 30.2 mg Co/kg/d; mice at 23-58.9 mg Co/kg/d	NOAEL = 24.8 mg/kg/d (mice); 81.7 mg Co/kg in screening study (mice)	Co (2+) generally non-mutagenic in bacterial assays; genotoxic/mutagenic/ clastogenic in mammalian systems
Cobalt stearate	LD50 = 9.82 gm/kg-	-	-	-	-
Dissociation Product: Stearic acid	LD50 = 4600 (rat) LD50 > 10,000 (rat)	50 g/kg/d for 24 weeks produced reversible lipogranulomas in rats; Severe effects in rats, including mortality, at 3000 ppm	-	-	Not mutagenic in bacterial assays
Fatty acids, tall oil, cobalt salts	-	-	-	-	-
Dissociation Product: Fatty acids, tall oil	LD50 > 10,000 (rat)	NOEL = 2500 mg/kg/d (rat 90-d, diet)	NOAEL = 5000 mg/kg/d (rat, 2 gen study)	NOAEL = 5000 mg/kg/d (rat, 2 gen study)	Not mutagenic in bacterial assays; clastogenic to mammalian cells but at cytotoxic concentrations

Table 6: Test Plan for Cobalt Stearate and Fatty Acids, Tall Oil, Cobalt Salts

Endpoint	Cobalt Stearate					Fatty Acids, Tall Oil, Cobalt Salts				
	Co stearate	Stearic acid	Co chloride	Data Used or Test required	OECD Guideline	FA,Tall Oil, Cobalt Salts	FA,Tall Oil	Co chloride	Data Used or Test required	OECD Guideline
Physicochemical Properties										
Melting point	Y	Y	Y	A		Y	NA	Y	A	
Boiling point	Y	Y	Y	A		Y	Y	Y	A	
Vapor pressure	N	Y	NA	DP		N	Y	NA	DP	
Partition coefficient	NA	Y	NA	NA		NA	Y	NA	NA	
Water Solubility	Y	Y	Y	A		Y	Y	Y	A	
Environmental Fate										
Photodegradation	N	Y	NA	DP		N	Y	NA	DP	
Stability in water	Y	Y	Y	A		Y	Y	Y	A	
Fugacity	N	Y	NA	DP		N	Y	NA	DP	
Biodegradation	N	Y	NA	Test	301	N	Y	NA	DP	
Ecotoxicity										
Acute Fish	N	N	Y	Test	203	N	Y	Y	R/DP	
Acute Daphnia	N	N	Y	Test	202	N	Y	Y	Test	202
Acute Algae	N	N	Y	Test	208	N	Y	Y	R/DP	
Mammalian Toxicity										
Acute	N	Y	Y	Test	425	N	Y	Y	Test	425
Repeated Dose	N	Y	Y	Test	422	N	Y	Y	R/DP	
Reproductive	N	N	Y	Test	422	N	Y	Y	R/DP	
Developmental	N	N	Y	Test	422	N	Y	Y	R/DP	
Genetic Toxicity (Bacteria)	N	Y	Y	DP		N	Y	Y	DP	
Genetic Toxicity (Mammalian)	N	N	Y	Test	473	N	Y	Y	Test	473

Y = Acceptable data available
N = No acceptable data available
NA = Not applicable due to physical/chemical properties of the substance
A = Endpoint requirement fulfilled with adequate existing data
Test = Endpoint requirements to be fulfilled with testing
DP = Endpoint requirements to be fulfilled using data for dissociation products
R = Use of category approach, e.g. that these two compounds are essentially the same and toxicity for one salt can be predicted from data for the other salt, when dissociation product data is available.

APPENDIX A

COBALT STEARATE ROBUST SUMMARIES

1. General Information

ID 6865-35-6
Date January 31, 2005

1.0 SUBSTANCE INFORMATION

Generic Name	:	Cobalt Stearate
Chemical Name	:	
CAS Registry No.	:	13586-84-0
Component CAS Nos.	:	
EINECS No.	:	
Structural Formula	:	$Co(C_{18}H_{35}O_2)_2$
Molecular Weight	:	625.9
Synonyms and Tradenames	:	Octadecanoic acid, cobalt salt; stearic acid, cobalt salt

2.1 MELTING POINT

Type	:	Melting Point/Melting Range Determination
Guideline/method	:	OECD 102; EPA OPPTS 830.7200
Value	:	45.1º to 79.3°C
Decomposition	:	Starts at 177°C
Sublimation	:	
Year	:	2003
GLP	:	Yes
Test substance	:	Cobalt stearate, batch H08 M23, 9.41% cobalt, purple solid, provided by Alfa Aesar
Method	:	OECD 102, Melting Point/Melting Range, July 1995; EPA Product Properties Test Guidelines, OPPTS 830.7200, Melting Point/Melting Range, March 1998
Method detail	:	A differential scanning colorimeter (DSC 821, Fa, Mettler Toledo) was used to determine the melting point/range (the temperature or temperature range at which phase transition from solid to liquid state occurs). A preliminary test was conducted at a heating rate of 20 K/min from 25ºC to 400ºC and the quantities of heat absorbed or released were measured and recorded. The weight and appearance of the sample were recorded before and after the test. Based upon the preliminary test results, two definitive runs were made at a heating rate of 5 K/min from 25ºC to 120ºC to determine the onset and end of the endothermic reaction.
Result	:	The melting range was determined from the mean of two definitive runs to be between 45.1ºC and 79.3ºC (318.3 K and 340.7 K)
Remark	:	**Supporting data for dissociation products:** **Acid:** The melting point reported for stearic acid is 69 - 70°C (Appendix D). **Metal:** The melting point reported for cobalt chloride is 735ºC (Appendix C).
Reliability	:	[1] Reliable without restriction
Reference	:	Tognucci, A., 2003. Determination of the Melting Point/Melting Range of Cobalt Stearate, RCC Study No. 849123, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.2 BOILING POINT

Type	:	Boiling Point/Boiling Range Determination
Guideline/method	:	OECD 103; EPA OPPTS 830.7220
Value	:	Decomposition observed before boiling could occur
Decomposition	:	Starts at 177°
Year	:	2003
GLP	:	Yes
Test substance	:	Cobalt stearate, batch H08 M23, 9.41% cobalt, purple solid, provided by Alfa Aesar
Method	:	OECD 103, Boiling Point, 1995; EPA Product Properties Test Guidelines, OPPTS 830.7220, Boiling Point/Boiling Range, August 1996
Method detail	:	A differential scanning colorimeter (DSC 821, Fa, Mettler Toledo) was used to determine the boiling point/range (the temperature or temperature range at which the vapor pressure of a liquid is the same as the standard pressure). A preliminary test was conducted at a heating rate of 20 K/min from 25ºC to 400ºC and the quantities of heat absorbed or released were measured and recorded. The weight and appearance of the sample were recorded before and after the test. A definitive run was made at a heating rate of 5 K/min from 130ºC to 300ºC; however no peak was observed from which boiling could be deduced.
Result	:	The boiling point was not observed because the test material decomposed prior to boiling.

Remark	:	**Supporting data for dissociation products:** **Acid:** The reported boiling point for stearic acid is 383 °C (Appendix D). **Metal:** The reported boiling point for cobalt chloride is 1,049ºC (Appendix C).
Reliability	:	[1] Reliable without restriction
Reference	:	Tognucci, A., 2003. Determination of the Boiling Point/Boiling Range of Cobalt Stearate, RCC Study No. 849124, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.3 DENSITY

Type	:	
Guideline/method	:	
Value	:	1.035
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** Reported value for stearic acid is 0.9408 at 20°C (HSDB 8/16/02). **Metal:** Reported value for cobalt chloride is 3.367 at 25ºC (Appendix C).
Reliability	:	
Reference		Certificate of Analysis for Cobalt Stearate, Lot Number H08M23, 9.41% cobalt, prepared by Alfa Aesar, Ward Hill, MA.

2.4 VAPOR PRESSURE

Type	:	
Guideline/method	:	
Value	:	hPa at °C
Decomposition	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** The reported vapor pressure for stearic acid is 1.33 hPa at 173.7°C (Appendix D).
Reliability	:	
Reference	:	

2.5 PARTITION COEFFICIENT

Type	:	
Guideline/method	:	
Partition coefficient	:	
Log Pow	:	at °C
pH value	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	

Result	:	
Remark	:	Determination of octanol/water partition coefficient (Kow) is inappropriate for metal carboxylate compounds such as cobalt stearate. Kow is determined on unionized, undissociated chemicals. Due to the complex water chemistry of cobalt stearate, and the presence of dissociated ionized constituents, measuring Kow would be extremely difficult if not impossible, and would not provide meaningful data. A worst-case estimate of log Kow, calculated for the salt ion pairs using EPIWIN, is 15.1; however, this value most probably over-predicts the potential for bioaccumulation of cobalt stearate under environmentally-relevant conditions. **Supporting data for dissociation products:** **Acid:** Log Kow for stearic acid is reported as 8.42 (Appendix D). **Metal:** not applicable (ionizes in water)
Reliability	:	
Reference	:	

2.6.1 SOLUBILITY IN WATER

Type	:	Water Solubility Determination
Guideline/method	:	OECD 105; EPA OPPTS 830.7840
Value	:	6.4 mg/L at 20ºC
pH value	:	
concentration	:	at °C
Temperature effects	:	
Examine different pol.	:	
PKa	:	at °C
Description	:	
Stable	:	
Deg. product	:	
Year	:	2003
GLP	:	Yes
Test substance	:	Cobalt stearate, Batch H08 M23, 9.41% cobalt, purple solid, provided by Alfa Aesar
Deg. products CAS#	:	
Method	:	OECD 105, Water Solubility, 1995; EPA Product Properties Test Guidelines, OPPTS 830.7840, Water Solubility: Column Elution Method, Shake Flask Method, 1998.
Method detail	:	The results of a preliminary test using a simplified flask method indicated the solubility was below 10 mg/L; therefore, the column elution method was used in the definitive test. The column was prepared by adding 6.05 g of glass beads into a flask, adding 0.120 g ground test material and mixing for 5 minutes. This was then poured into the elution column which was subsequently filled with water and equilibrated for approximately 2 hours. A circulation pump was used to elute the cobalt stearate from the carrier material. Temperature was 20ºC. The flow rate was 0.52 mL/min for 71 hours, followed by a period of 24 hours at 0.26 mL/min. The apparatus was run until equilibration of the saturation column was obtained, defined by at least five successive samples whose concentrations do not differ more than 30%. The column eluate was sampled at 1 hour intervals to determine the concentration of cobalt, using atomic absorption spectroscopy.
Result	:	Based on the results of 12 samples, the cobalt solubility was 0.6 mg/L (SD ± 0 mg/L) which corresponds to a water solubility of cobalt stearate of 6.4 mg/L (calculated based on cobalt content of 9.41%). The pH during the test ranged from 7.04 to 7.98.
Remark	:	**Supporting data for dissociation products:** **Acid:** The reported water solubility for stearic acid is 0.568 mg/L at 25 °C (Appendix D).

		Metal: The reported water solubility for cobalt chloride is 450 g/L at 7ºC (Appendix C).
Reliability	:	[1] Reliable without restriction
Reference	:	Tognucci, A., 2003. Determination of the Water Solubility of Cobalt Stearate, RCC Study No. 849126, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.7 FLASH POINT

Type	:	
Guideline/method	:	
Value	:	°C
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

3.1.1 PHOTODEGRADATION

Type		
Guideline/method	:	
Light source	:	
Light spectrum	:	
Relative intensity	:	based on
Spectrum of substance	:	lambda (max, >295nm) : epsilon (max) : epsilon (295) :
Conc. of substance	:	at °C
DIRECT PHOTOLYSIS		
Halflife (t1/2)	:	
Degradation	:	% after
Quantum yield	:	
INDIRECT PHOTOLYSIS		
Sensitizer	:	
Conc. of sensitizer	:	
Rate constant	:	
Degradation	:	
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid**: Half life of 0.5 days for stearic acid, calculated using AopWin v1.91 (Appendix D). **Metal:** not applicable, metal does not degrade
Reliability	:	
Reference	:	

3.1.2 DISSOCIATION

Type	:	Dissociation constant determination
Guideline/method	:	OECD 112
pKa	:	7.50 at 20°C
Year	:	2002
GLP	:	Yes
Test substance	:	Cobalt stearate, lot number F26L13, received from Alfa Aesar. Dark pellets, purity of 9.6% cobalt.
Approximate water solubility	:	0.17 mg/L, determined by Inductively Coupled Plasma Atomic Emission Spectrometry during preliminary study
Method	:	OECD Guideline 112, Dissociation Constants in Water
Method detail	:	Three replicate samples of cobalt stearate were prepared at a nominal concentration of 0.10 mg/L by fortification of 100 mL of degassed water (ASTM Type II) with a 0.10 mg/mL stock solution of the test substance in tetrahydrofuran. Each sample was titrated against 0.00025 N sodium hydroxide while maintained at a test temperature of 20±1°C. At least 10 incremental additions were made before the equivalence point and the titration was carried past the equivalence point. Values of pK were calculated for a minimum of 10 points on the titration curve. Phosphoric acid and 4-nitrophenol were used as reference substances.
Result	:	Mean (N = 3) pKa value was 7.50 (SD = 0.0356) at 20°C

Remark	:	The results indicate that dissociation of the test substance will occur at environmentally-relevant pH values (approximately neutral) and at physiologically-relevant pH values (approximately 1.2).
Reliability	:	[1] Reliable without restriction.
Reference	:	Lezotte, F.J. and W.B. Nixon, 2002. Determination of the dissociation constant of cobalt stearate, Wildlife International, Ltd. Study No. 534C-113, conducted for the Metal Carboxylates Coalition.

3.2.1 MONITORING DATA

Type of measurement	:	
Media	:	
Concentration	:	
Substance measured	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

3.3.1 TRANSPORT (FUGACITY)

Type	:	
Media	:	
Air	:	% (Fugacity Model Level I)
Water	:	% (Fugacity Model Level I)
Soil	:	% (Fugacity Model Level I)
Biota	:	% (Fugacity Model Level II/III)
Soil	:	% (Fugacity Model Level II/III)
Year	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid**: Using EPIWIN v. 3.11, the Level III fugacity model predicts distribution of stearic acid primarily to sediment (63.3%), followed by soil (28.9%), water (7.19%) and air (<1%). See Appendix D.
Reliability	:	
Reference	:	

3.5 BIODEGRADATION

Type	:	
Guideline/method	:	
Inoculum	:	
Concentration	:	related to related to
Contact time	:	
Degradation	:	(±) % after day(s)
Result	:	
Kinetic of test subst.	:	% (specify time and % degradation) % % %

		%
Control substance	:	
Kinetic	:	%
		%
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid**: Stearic acid is readily biodegradable in activated sludge under aerobic conditions: 77% degraded in 28 days in BOD test; 95% in 21 days in Sturm CO_2 evolution test; reported half-life of 3 -10 days in additional studies (Appendix D). **Metal:** not applicable, metal does not degrade.
Reliability	:	
Reference	:	

3.7 BIOCONCENTRATION

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	at °C
Concentration	:	
BCF	:	
Elimination	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

4.1 ACUTE TOXICITY TO FISH

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	
NOEC	:	
LC0	:	
LC50	:	
LC100	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Acid:** For stearic acid, the LT50 was > 96 hours at 12 mg/L for *Oncorhynchus kisutch* (Appendix D). **Metal:** For cobalt chloride, the 96-h LC50 was 1.41 mg Co/L for the highly sensitive rainbow trout, *Onchorynchus mykiss*. Toxicity to other fish species ranges from LC50 values of 22 – 333 mg Co/L. Toxicity is dependent upon water hardness (Appendix C).
Reliability	:	
Reference	:	

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	
NOEC	:	
EC0	:	
EC50	:	
EC100	:	
Other	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Metal:** For cobalt chloride, the 48-h EC50 for *Daphnia magna* was 1.52 mg Co/L. In other studies, and with other species, 48-h LC50 values ranged from 1.52 – 5.5 mg Co/L. (Appendix C).
Reliability	:	
Reference	:	

4.3 TOXICITY TO AQUATIC PLANTS (E.G., ALGAE)

Type	:	
Guideline/method	:	
Species	:	
Endpoint	:	
Exposure period	:	
NOEC	:	
LOEC	:	
EC0	:	
EC10	:	
EC50	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Metal:** For cobalt chloride, the 96-h EC50 for *Chorella vulgaris* was 0.52 mg Co/L. Other aquatic plants were less sensitive with EC50 values from 16.9 – 23.8 mg Co/L. (Appendix C).
Reliability	:	
Reference	:	

4.4 CHRONIC TOXICITY TO FISH

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	
NOEC	:	
LOEC	:	
LC0	:	
LC50	:	
LC100	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

4.5 CHRONIC TOXICITY TO AQUATIC INVERTEBRATES

Type	:	

Guideline/method	:
Species	:
Exposure period	:
NOEC	:
LOEC	:
EC0	:
EC50	:
EC100	:
Other	:
Other	:
Limit test	:
Analytical monitoring	:
Year	:
GLP	:
Test substance	:
Method	:
Method detail	:
Result	:
Remark	:
Reliability	:
Reference	:

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

In vitro/in vivo	:	
Type	:	
Guideline/method	:	
Species	:	
Number of animals	:	
Males	:	
Females	:	
Doses	:	
Males	:	
Females	:	
Vehicle	:	
Route of administration	:	
Exposure time	:	
Product type guidance	:	
Decision on results on acute tox. tests	:	
Adverse effects on prolonged exposure	:	
Half-lives	:	1st.: 2nd.: 3rd.:
Toxic behavior	:	
Deg. product	:	
Deg. products CAS#	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Metal:** Absorption of cobalt in the digestive tract is influenced by the chemical form of the metal, with increasing solubility resulting in increased absorption. Approximately 13-34% of cobalt chloride, a soluble form, is absorbed in the gut of rats, but absorption in the gut may be increased in iron deficient individuals. Following oral exposure, cobalt is eliminated primarily in feces and secondarily in urine. For the more soluble forms of cobalt, e.g., cobalt chloride, 70 – 80% of the administered dose is eliminated in the feces. For absorbed cobalt, elimination is rapid primarily in the urine (Barceloux, D.G. (1999) Cobalt. Clin. Tox. 37(2):201-206). Elimination is biphasic or triphasic. The terminal phase involves a very small residual level of cobalt and has a half-life in years (Appendix C).
Reliability	:	
Reference	:	

5.1.1 ACUTE ORAL TOXICITY

Type	:	Single dose
Guideline/Method	:	
Species	:	Rat
Strain	:	
Sex	:	Both male and females
Number of animals	:	Five per dose level (30 overall)
Vehicle	:	Propylene Glycol
Doses	:	1.0, 2.0, 4.0, 8.0, 16.0, and 32.0 gm /kg

LD50	:	9.82 gm /kg (± 95% CI 7.45-12.95 gm /kg)
Year	:	1977
GLP	:	No
Test substance	:	Co Stearate
Method	:	Oral gavage
Method detail	:	Young rats 200-300 gms wererandomized and dosed via oral gavage and observed for 14 days
Result	:	Observations included: lethargy, unkempt coat, diarrhea, nasal hemorrhage, and at 16.0 gm /kg loss of mototr control . In the high dose the mortalities occurred within 24 hours. At 16.0 and 8.0 gm /kg moptalities occurred between 4 and 6 days post treatment.
Remark	:	**Supporting information for dissociation products:** **Acid:** Rat LD50 = 4600 mg/kg bw for stearic acid (Appendix D). Additional data: Male rats (5 males per treatment) were dosed with 0.464 to 10.0 g/kg of eutectic (triple pressed) stearic acid. The LD50 was reported as >10.0 g/kg (>10,000 mg/kg). Reference: Cosmetic, Toiletries, and Fragrance Association (1987) Cosmetic Ingredient Review, Final Report on the Safety Assessment of Oleic Acid, Lauric Acid, Palmitic Acid, Myristic Acid and Stearic Acid. J. Am. Coll. Toxicol. Vol. 6, No. 3, pp321-401. (Subsequently referred to as CTFA#3.) **Metal:** Reported LD50s of cobalt chloride to rats range from 42.4 to 190 mg $CoCl_2$/kg bw (equivalent to 19.8 to 85.5 mg Co/mg bw). Toxicity of cobalt sulfate is reported to be similar to the chloride with oral LD50s for rats ranging from 123 to 161 mg/kg bw (equivalent to 46.7 to 61.2 mg Co/kg bw). For the mouse, LD50 values are 89.3 and 123 mg/kg for cobalt chloride and cobalt sulfate, respectively, which are equivalent to 40.2 and 56.7 mg/kg bw when expressed as the metal only (ATSDR Sept 2001 Draft; see Appendix C).
Reliability	:	(2) Reliable with resptriction. Consucted prior to the the implementation of GLP.
Reference	:	Study conducted by Bio-Toxicology Laboratories, Inc. Moorestown, NJ, for The Shepherd Chemical Company Reported May 31, 1977.

5.1.2 ACUTE INHALATION TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Exposure time	:	
LC50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** No acute inhalation studies have been located for cobalt chloride.
Reliability	:	
Reference	:	

5.1.3 ACUTE DERMAL TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
LD50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Acid:** Stearic acid, 10-100 mM in olive oil was dosed intradermally in guinea pigs and rabbits which resulted in mild erythema and slight induration of skin. CTFA#3 ref 157. Stearic acid as a 20% formulations was applied at 2.0 ml/kg of product to abraded/intact sites on the backs of rabbits. After four weeks no mortaltities and slight edema and sesqumation were observed. CTFA#3 ref 163. **Metal:** Increased proliferation of lymphatic cells was seen in rats, mice and guinea pigs dermally exposed to cobalt chloride, with LOAEL values ranging from 9.6 to 14.7 mg Co/kg/day (Appendix C).
Reliability	:	
Reference	:	

5.2.1 SKIN IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** Dermatitis is a common result of dermal exposure to cobalt in humans and has been verified in a large number of studies. The dermatitis is probably caused by an allergic reaction to cobalt. (Appendix C).
Reliability	:	
Reference	:	

5.2.2 EYE IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Dose	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	**Supporting information for dissociation products:** **Acid:** Stearic acid (eutectic, commercial grade) was applied to the eyes of albino rabbits following the Draise method. Results ranged from no irritation to mild conjunctival erythema in 2 rabbits subsiding by 72 hours. Stearic acid in various formulations at lower strengths showed similar results (CTFA#3).
Remark	:	
Reliability	:	
Reference	:	

5.4 REPEATED DOSE TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Route of admin.	:	
Exposure period	:	
Frequency of treatment	:	
Post exposure period	:	
Doses	:	
Control group	:	
NOAEL	:	
LOAEL	:	
Other	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Acid:** Rats fed for 24 weeks with stearic acid (50 g/kg/day) developed foreign body type reaction in perigenital fat. Lipogranulomas were oberved to be reversible. Rats fed stearic acid (3000 ppm) for 30 weeks developed anorexia, severe pulmonary infection, and high mortality. No significant pathological lesions were observed. (CTFA#3 ref 151,152). (Appendix D). **Metal:** Repeated oral dosing of rats for 150-210 days with cobalt chloride

at 4 and 10 mg Co/kg indicated a LOAEL of 4 mg Co/kg, based upon increased organ weights. Eight weeks' oral exposure of rats to cobalt chloride hexahydrate indicated a LOAEL of 2.5 mg Co/kg (changes in hemoglobin and red blood cell count) and a NOAEL of 0.6 mg Co/kg. Other studies using repeated oral dosing for periods ranging from 12-16 days up to 7 months indicated LOAELs ranging from 0.5 to 30.2 mg Co/kg/day (as cobalt chloride) based upon observations such as reduced weight gain, increases in some organ weights (heart, liver and lungs); increased hematocrit, hemoglobin, and RBCs; renal tubular necrosis; and various changes on cardiac physiology (left ventricular hypertrophy, impaired ventricular function, and degeneration of myofibrils). Cardiac effects were observed in rats at LOAELs ranging from 8.4 to 12.4 mg Co/kg/day, for cobalt sulfate or cobalt chloride, with exposure periods of 3 weeks to 6 months (Appendix C).

Reliability :
Reference :

5.5 GENETIC TOXICITY 'IN VITRO'

Type :
Guideline/method :
System of testing :
Species :
Strain :
Test concentrations :
Cytotoxic concentr. :
Metabolic activation :
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark :

Supporting information for dissociation products:
Acid: Stearic acid was not mutagenic in *S. typhimurium* with and without metabolic activation. Stearic acid was tested for mutagenicity using the Ames test with *Salmonella typhumurium* strains TA98, TA100, TA1535, TA1537, TA1538. Spot tests were performed suing 50 mg/ml stearic acid suspensions in the distilled waster (50 µg/plate) with and without microsomal activation from hepatic S9 fractions from rats induced with Aroclor 1254 (50 µg/plate). Positive controls were 2-aminoanthracene and 4-nitro—o-phenylenediamine in dimethyl sulfoxide, 9-aminoacridinein ethanol, and sodium azide in distilled water with and without metabolic acitivation. (CTFA#3.)
MetalCobalt compounds with a valence state of II, the form of cobalt released by dissociation of cobalt chloride, are reported to be generally non-mutagenic in *in vitro* bacterial assays, although weak positive responses have been observed under some conditions (Appendix C).

Reliability :
Reference :

5.6 GENETIC TOXICITY 'IN VIVO'

Type :
Guideline/method :
Species :
Strain :

Sex	:	
Route of admin.	:	
Exposure period	:	
Doses	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Metal:** Cobalt compounds, including soluble salts, are observed to be clastogenic (cause chromosomal aberrations) in a range of mammalian assay systems. Increased micronucleus formation was observed following i.p. injection of 12.4 and 22.3 mg Co/kg (as cobalt chloride), but not after injection of 6.19 mg Co/kg (NOEL). In the mouse micronucleus test, a dose-dependent increase in the frequency of micronucleated polychromatic erythrocytes was observed with i.p. exposure to cobalt chloride hexahydrate (Appendix C).
Reliability	:	
Reference	:	

5.8.2 DEVELOPMENTAL TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Route of admin.	:	
Exposure period	:	
Frequency of treatment	:	
Duration of test	:	
Doses	:	
Control group	:	
NOAEL maternal tox.	:	
NOAEL teratogen.	:	
Other	:	
Other	:	
Other	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting information for dissociation products:** **Metal:** In a developmental toxicity study with cobalt chloride exposure (5.4 to 21.8 mg Co/kg/day) in rats from gestation day 14 to lactation day 21, stunted pup growth was seen at all dose levels. However, maternal toxicity was observed in conjunction with effects on the offspring. This growth effect was considered to be a secondary or indirect effect rather than a direct effect of cobalt on the fetus. No teratogenic effects were observed. Another study in rats provided a NOAEL of 24.8 mg Co/kg/day for cobalt chloride exposure from gestation days 6-15. In a screening study, no effects were observed on fetal growth or survival in mice exposed to 81.7 mg Co/kg/day as cobalt chloride during gestation days 8-12 (Appendix C).

Reliability	:
Reference	:

5.8.3 TOXICITY TO REPRODUCTION

Type	:
Guideline/method	:
In vitro/in vivo	:
Species	:
Strain	:
Sex	:
Route of admin.	:
Exposure period	:
Frequency of treatment	:
Duration of test	:
Doses	:
Control group	:
Year	:
GLP	:
Test substance	:
Method	:
Method detail	:
Result	:
Remark	: **Supporting information for dissociation products:** **Metal:**Male mice exposed to cobalt chloride hexahydrate in drinking water for 12-13 weeks demonstrated effects on testicular weight and sperm concentration at all dose levels (23 - 58.9 mg Co/kg bw). Rats exposed to 20 mg Co/kg bw (as cobalt chloride hexahydrate) through the diet showed degenerative and necrotic lesions in seminiferous tubules and testicular atrophy (Appendix C).
Reliability	:
Reference	:

6.0 OTHER INFORMATION

6.1 CARCINOGENICITY

Supporting information for dissociation products:
Metal: The US National Toxicology Program does not recognize cobalt as a human carcinogen, but IARC has classified cobalt and cobalt compounds as possibly carcinogenic to humans (Class 2B) based on sufficient evidence that cobalt metal powder and cobaltous oxide are carcinogenic in animals (Barceloux 1999, ATSDR Sept 2001 Draft). "No studies were located regarding carcinogenic effects in animals after oral exposure to stable [non-radioactive] cobalt." (ATSDR Sept 2001 Draft).

APPENDIX B

FATTY ACID, TALL OIL, COBALT SALTS ROBUST SUMMARIES

1. General Information

ID 61789-52-4

Date January 31, 2005

1.0 SUBSTANCE INFORMATION

Generic Name	:	
Chemical Name	:	Fatty acids, tall oil, cobalt salts
CAS Registry No.	:	61789-52-4
Component CAS Nos.	:	
EINECS No.	:	
Structural Formula	:	
Molecular Weight	:	
Synonyms and Tradenames	:	Cobalt tallate; Tall oil fatty acids, cobalt salts
References	:	

2.1 MELTING POINT

Type	:	Melting Point/Melting Range Determination
Guideline/method	:	OECD 102; EPA OPPTS 830.7200
Value	:	-38 to -39°C
Decomposition	:	at °C
Sublimation	:	
Year	:	2003
GLP	:	Yes
Test substance	:	Fatty acids, tall oil, cobalt salts, Lab batch 1022-49, 8.85% cobalt, very tacky red-purple solid, provided by OMG Americas
Method	:	OECD 102, Melting Point/Melting Range, July 1995; EPA Product Properties Test Guidelines, OPPTS 830.7200, Melting Point/Melting Range, March 1998
Method detail	:	The freezing point, defined as the temperature at which phase transition from liquid to solid state at normal atmospheric temperature occurs, corresponds to the melting point. To determine the freezing point, 5 mL of test material was preheated in a waterbath at about 80ºC and then cooled using acetone and dry ice until solidification. A thermocouple probe in the center of the sample was used to measure temperature over time; the physical state was observed as well. The test was run in duplicate.
Result	:	The freezing point (melting point) was determined to be between -38ºC and -39ºC (equal to 234 – 235 K)
Remark	:	**Supporting data for dissociation products:** **Metal**: The melting point reported for cobalt chloride is 735ºC (Appendix C).
Reliability	:	[1] Reliable without restriction
Reference	:	Tognucci, A., 2003. Determination of the Melting Point/Melting Range of Fatty Acids, Tall Oil, Cobalt Salts, RCC Study No. 849114, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.2 BOILING POINT

Type	:	Boiling Point/Boiling Range Determination
Guideline/method	:	OECD 103; EPA OPPTS 830.7220
Value	:	Boiling point was not observed
Decomposition	:	
Year	:	2003
GLP	:	Yes
Test substance	:	Fatty acids, tall oil, cobalt salts, Lab batch 1022-49, 8.85% cobalt, very tacky red-purple solid, provided by OMG Americas
Method	:	OECD 103, Boiling Point, 1995; EPA Product Properties Test Guidelines, OPPTS 830.7220, Boiling Point/Boiling Range, August 1996
Method detail	:	A differential scanning colorimeter (DSC 821, Fa, Mettler Toledo) was used to determine the boiling point/range (the temperature or temperature range at which the vapor pressure of a liquid is the same as the standard pressure). A preliminary test was conducted at a heating rate of 20 K/min from 25ºC to 400ºC and the quantities of heat absorbed or released were measured and recorded. The weight and appearance of the sample were recorded before and after the test. A definitive run was made at a heating rate of 10 K/min; however no peak was observed from which boiling could be deduced.
Result	:	The boiling point was not observed.
Remark	:	**Supporting data for dissociation products:** **Acid**: For tall oil fatty acids, the boiling point is reported as approx. 160 - 210 °C at 6.6 hPa. Union Camp Chemicals (Durham. UK); cited in year 2000 IUCLID dataset.

Metal: The reported boiling point for cobalt chloride is 1,049ºC (Appendix C).

Reliability : [1] Reliable without restriction

Reference : Tognucci, A., 2003. Determination of the Boiling Point/Boiling Range of Fatty Acids, Tall Oil, Cobalt Salts, RCC Study No. 849115, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.3 DENSITY

Type : Specific gravity
Guideline/method :
Value : 1.02 at 25°C
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark : **Supporting data for dissociation products:**
Metal: Reported value for cobalt chloride is 3.367 at 25ºC (Appendix C).
Reliability :
Reference Material Safety Data Sheet for cobalt tallate, OMG Americas, Inc.

2.4 VAPOR PRESSURE

Type :
Guideline/method :
Value : hPa at °C
Decomposition :
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark : **Supporting data for dissociation products:**
Acid: For tall oil fatty acids, the vapor pressure is negligible at 25°C. Union Camp Chemicals (Durham. UK); cited in year 2000 IUCLID dataset.
Reliability :
Reference :

2.5 PARTITION COEFFICIENT

Type :
Guideline/method :
Partition coefficient :
Log Pow : at °C
pH value :
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark : Determination of octanol/water partition coefficient (Kow) is inappropriate for metal carboxylate compounds such as fatty acids, tall oil, cobalt salts. Kow is determined on unionized, undissociated chemicals. Due to the complex

water chemistry of fatty acids, tall oil, cobalt salts, and the presence of dissociated ionized constituents, measuring Kow would be extremely difficult if not impossible, and would not provide meaningful data.
Supporting data for dissociation products:
Acid: When tested according to OECD Test Method 117, at pH 2, the log P_{ow} values for seven compounds in tall oil fatty acid were 4.4, 7.0, 7.3, 7.5, 7.7, 8.0, and 8.3. At pH 7.5, the log P_{ow} values for six compounds in tall oil fatty acid were 3.6, 3.8, 4.2, 4.5, 4.7, and 7.4. (Dybdahl, H.P. 1993). See robust summary prepared by the Pine Chemicals Association (Appendix E).
Metal: not applicable (ionizes in water).

Reliability :
Reference :

2.6.1 SOLUBILITY IN WATER

Type	:	Water Solubility Determination
Guideline/method	:	OECD 105; EPA OPPTS 830.7840
Value	:	149 mg/L at 20°C
pH value	:	
concentration	:	at °C
Temperature effects	:	
Examine different pol.	:	
PKa	:	at °C
Description	:	
Stable	:	
Deg. product	:	
Year	:	2003
GLP	:	Yes
Test substance	:	Fatty acids, tall oil, cobalt salts, Lab Batch 1022-49, 8.85% cobalt, very tacky red-purple solid, provided by OMG Americas
Deg. products CAS#	:	
Method	:	OECD 105, Water Solubility, 1995; EPA Product Properties Test Guidelines, OPPTS 830.7840, Water Solubility: Column Elution Method, Shake Flask Method, 1998.
Method detail	:	The results of a preliminary test using a simplified flask method indicated the solubility was below 10 mg/L; therefore, the column elution method was used in the definitive test. The column was prepared by adding 6.09 g of glass beads into a flask, adding 0.12 g of test material dissolved in 5 mL dichloromethane, and evaporating the solvent under a stream of nitrogen. This was then poured into the elution column which was subsequently filled with water and equilibrated for approximately 2 hours. A circulation pump was used to elute the test material from the carrier material. Temperature was 20ºC. The flow rate was 0.52 mL/min for 120 hours, followed by a period of 23 hours at 0.26 mL/min. The apparatus was run until equilibration of the saturation column was obtained, defined by at least five successive samples whose concentrations do not differ more than 30%. The column eluate was sampled at 1 hour intervals to determine the concentration of cobalt, using atomic absorption spectroscopy.
Result	:	Based on the results of 12 samples, the cobalt solubility was 13.2 mg Co/L (SD ± 2.8 mg/L) which corresponds to a water solubility of fatty acids, tall oil, cobalt salts of 149 mg FA Tall Oil Co Salt/L (calculated based upon cobalt content of 8.85% w/w). The pH during the test ranged from 5.59 to 5.62.
Remark	:	**Supporting data for dissociation products:** **Acid**: The water solubility of tall oil fatty acid, in its entirety as a complex mixture, was reported as 12.6 mg/L (Dinwoodie, N.B., 2003; see robust summary prepared by the Pine Chemicals Association in Appendix E).

Metal: The reported water solubility for cobalt chloride is 450 g/L at 7°C (Appendix C).

Reliability : [1] Reliable without restriction

Reference : Tognucci, A., 2003. Determination of the Water Solubility of Fatty Acids, Tall Oil, Cobalt Salts, RCC Study No. 849117, conducted for the Metal Carboxylates Coalition by RCC Ltd., Switzerland.

2.7 FLASH POINT

Type :
Guideline/method :
Value : °C
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark :
Reliability :
Reference :

3.1.1 PHOTODEGRADATION

Type		
Guideline/method	:	
Light source	:	
Light spectrum	:	
Relative intensity	:	based on
Spectrum of substance	:	lambda (max, >295nm) :
		epsilon (max) :
		epsilon (295) :
Conc. of substance	:	at °C
DIRECT PHOTOLYSIS		
Halflife (t1/2)	:	
Degradation	:	% after
Quantum yield	:	
INDIRECT PHOTOLYSIS		
Sensitizer	:	
Conc. of sensitizer	:	
Rate constant	:	
Degradation	:	
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** AOPWIN v.191 was used to calculate photodegradation for two major components of fatty acids, tall oil. The half-life for oleic acid was 1-2 hours and the half-life for linoleic acid was 0.7 -1 hours. **Metal:** not applicable, metal does not degrade.
Reliability	:	(1) Reliable without restriction
Reference	:	

3.1.2 DISSOCIATION

Type	:	Dissociation constant determination
Guideline/method	:	OECD 112
pKa	:	5.82 at 20°C
Year	:	2002
GLP	:	Yes
Test substance	:	Cobalt tallate, CAS number 61789-52-4, received from OMG. Dark solid, purity of 20.6% cobalt
Approximate water solubility	:	3.5 mg/L, determined by Inductively Coupled Plasma Atomic Emission Spectrometry during preliminary study
Method	:	OECD Guideline 112, Dissociation Constants in Water
Method detail	:	Three replicate samples of cobalt tallate were prepared at a nominal concentration of 1.5 mg/L by fortification of 100 mL of degassed water (ASTM Type II) with a 1.0 mg/mL stock solution of the test substance in methanol. Each sample was titrated against 0.00025 N sodium hydroxide while maintained at a test temperature of 20±1°C. At least 10 incremental additions were made before the equivalence point and the titration was carried past the equivalence point. Values of pK were calculated for a minimum of 10 points on the titration curve. Phosphoric acid and 4-nitrophenol were used as reference substances.

Result	:	Mean (N = 3) pKa value was 5.82 (SD = 0.108) at 20°C
Remark	:	The results indicate that dissociation of the test substance will occur at environmentally-relevant pH values (approximately neutral) and at physiologically-relevant pH values (approximately 1.2).
Reliability	:	[1] Reliable without restriction.
Reference		Lezotte, F.J. and W.B. Nixon, 2002. Determination of the dissociation constant of tall oil, cobalt salts, Wildlife International, Ltd. Study No. 534C-117, conducted for the Metal Carboxylates Coalition.

3.2.1 MONITORING DATA

Type of measurement	:
Media	:
Concentration	:
Substance measured	:
Method	:
Method detail	:
Result	:
Remark	:
Reliability	:
Reference	:

3.3.1 TRANSPORT (FUGACITY)

Type	:	
Media	:	
Air	:	% (Fugacity Model Level I)
Water	:	% (Fugacity Model Level I)
Soil	:	% (Fugacity Model Level I)
Biota	:	% (Fugacity Model Level II/III)
Soil	:	% (Fugacity Model Level II/III)
Year	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid**: EPIWIN v3.11 was used to determine fugacity (Level III) for two major components of fatty acids, tall oil. Results are:

	Mass amount (%)	Half-life (hr)	Emissions (kg/hr)
Oleic acid			
Air	0.0999	1.3	1000
Water	7.49	360	1000
Soil	28.1	360	1000
Sediment	64.3	1440	0
Persistence time: 616 hr			
Linoleic acid			
Air	0.0546	0.691	1000
Water	8.07	360	1000
Soil	28.7	360	1000
Sediment	63.1	1440	0
Persistence time: 603 hr			

Reliability	:	(1) Reliable without restriction
Reference	:	

3.5 BIODEGRADATION

Type	:	
Guideline/method	:	
Inoculum	:	
Concentration	:	related to related to
Contact time	:	
Degradation	:	(±) % after day(s)
Result	:	
Kinetic of test subst.	:	% (specify time and % degradation) % % %
Control substance	:	
Kinetic	:	% %
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** The biodegradability of tall oil fatty acids has been studied in several different tests. In a ready biodegradability closed bottle test (OECD 301D), the test material degraded 50% in 7 days and 56% in 28 days (Madsen, 1993). In a manometric respiratory test (OECD 301 F), the substance degraded 84% in 28 days (Aniol, 1999). In a ready biodegradability modified Sturm test (OPPTS 853.110), 74% of the test article degraded in 28 days (Sewell, 1994). See robust summaries prepared by the Pine Chemicals Association (Appendix E). **Metal:** not applicable, metal does not degrade.
Reliability	:	
Reference	:	

3.7 BIOCONCENTRATION

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	at °C
Concentration	:	
BCF	:	
Elimination	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

4.1 ACUTE TOXICITY TO FISH

Type	:
Guideline/method	:
Species	:
Exposure period	:
NOEC	:
LC0	:
LC50	:
LC100	:
Other	:
Other	:
Other	:
Limit test	:
Analytical monitoring	:
Year	:
GLP	:
Test substance	:
Method	:
Method detail	:
Result	:
Remark	: **Supporting data for dissociation products:** **Acid:** In a study conducted according to OECD 203, fathead minnows (*Pimephales promelas*) were exposed to water accommodated fractions of tall oil fatty acid. The 96-h LL50 was > 1000 mg/L, which was the highest loading rate tested. The NOEL was 1000 mg/L. (Kelly, 2002. See robust summary prepared by the Pine Chemicals Association (Appendix E). The 96-h LC50 for zebrafish is reported to be 10 to 20 mg/L for tall oil fatty acids. Arizona Chemical Company letter to U.S EPA dated November 2, 1999. [Available from the National Technical Information Service in microfiche OTS0559827, Initial submission letter from attorneys of Arizona Chemical Co. to USEPA regarding 17 health and ecotoxicity studies of various chemicals with attachments and dated 110299 (sanitized)]. **Metal:** For cobalt chloride, the 96-h LC50 was 1.41 mg Co/L for the highly sensitive rainbow trout, *Onchorynchus mykiss*. Toxicity to other fish species ranges from LC50 values of 22 – 333 mg Co/L. Toxicity is dependent upon water hardness (Appendix C).
Reliability	:
Reference	:

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type	:
Guideline/method	:
Species	:
Exposure period	:
NOEC	:
EC0	:
EC50	:
EC100	:
Other	:
Other	:
Other	:
Limit test	:
Analytical monitoring	:
Year	:
GLP	:

Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** In a study conducted according to OECD 202, Part 1, *Daphnia magna* were exposed to water accommodated fractions of tall oil fatty acid. The 48-h EL50 was > 1000 mg/L, which was the highest loading rate tested. The NOEL was 1000 mg/L. (Kelly, 2002. See robust summary in attached document prepared by the Pine Chemicals Association (Appendix E). The 48-h EC50 for *Daphnia magna* is reported as 55.7 mg/L for tall oil fatty acids. Arizona Chemical Company letter to U.S EPA dated November 2, 1999. [Available from the National Technical Information Service in microfiche OTS0559827, Initial submission letter from attorneys of Arizona Chemical Co. to USEPA regarding 17 health and ecotoxicity studies of various chemicals with attachments and dated 110299 (sanitized)]. **Metal:** For cobalt chloride, the 48-h EC50 value for *Daphnia magna* was 1.52 mg Co/L. In other studies, and with other species, 48-h LC50 values ranged from 1.52 – 5.5 mg Co/L (Appendix C).
Reliability	:	
Reference	:	

4.3 TOXICITY TO AQUATIC PLANTS (E.G., ALGAE)

Type	:	
Guideline/method	:	
Species	:	
Endpoint	:	
Exposure period	:	
NOEC	:	
LOEC	:	
EC0	:	
EC10	:	
EC50	:	
Other	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** In a study conducted according to OECD 201, the green alga *Selenastrum capricornutum* was exposed to water accommodated fractions of tall oil fatty acid. The 72-h EL50 based on area under the growth curve was 854 mg/L with a corresponding NOEL of 500 mg/L. The 72-h EL50 based on average specific growth rate was > 1000 mg/L with a corresponding NOEL of 750 mg/L. (Kelly, 2002. See robust summary in attached document prepared by the Pine Chemicals Association (Appendix E). The growth inhibition EC50 values for three algal species were reported to range from 0.79 to 9 mg/L for tall oil fatty acids. Arizona Chemical Company letter to U.S EPA dated November 2, 1999. [Available from the

National Technical Information Service in microfiche OTS0559827, Initial submission letter from attorneys of Arizona Chemical Co. to USEPA regarding 17 health and ecotoxicity studies of various chemicals with attachments and dated 110299 (sanitized)].
Metal: For cobalt chloride, the 96-h EC50 for *Chorella vulgaris* was 0.52 mg Co/L. Other aquatic plant species were less sensitive, with EC50 values from 16.9 – 23.8 mg Co/L (Appendix C).

Reliability :
Reference :

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

In vitro/in vivo	:	
Type	:	
Guideline/method	:	
Species	:	
Number of animals	:	
Males	:	
Females	:	
Doses	:	
Males	:	
Females	:	
Vehicle	:	
Route of administration	:	
Exposure time	:	
Product type guidance	:	
Decision on results on acute tox. tests	:	
Adverse effects on prolonged exposure	:	
Half-lives	:	1st: 2nd: 3rd:
Toxic behavior	:	
Deg. product	:	
Deg. products CAS#	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** Absorption of cobalt in the digestive tract is influenced by the chemical form of the metal, with increasing solubility resulting in increased adsorption. Approximately 13-34% of cobalt chloride, a soluble form, is absorbed in the gut of rats, but absorption in the gut may be increased in iron deficient individuals. Following oral exposure, cobalt is eliminated primarily in feces and secondarily in urine. For the more soluble forms of cobalt, e.g., cobalt chloride, 70 – 80% of the administered dose is eliminated in the feces. For absorbed cobalt, elimination is rapid primarily in the urine (Barceloux, D.G. (1999) Cobalt. Clin. Tox. 37(2):201-206). Elimination is biphasic or triphasic. The terminal phase involves a very small residual level of cobalt and has a half-life in years (Appendix C).
Reliability	:	
Reference	:	

5.1.1 ACUTE ORAL TOXICITY

Type	:	
Guideline/Method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	

Doses	:	
LD50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	**Supporting data for dissociation products:** **Acid:** The acute oral LD50 of tall oil fatty acids has been reported as >10,000 mg/kg in rats using a test procedure consistent with OECD Test Method 401. (Mallory, 1983). See robust summary in attached document prepared by the Pine Chemicals Association (Appendix E). **Metal:** Reported LD50s of cobalt chloride to rats range from 42.4 to 190 mg $CoCl_2$/kg bw (equivalent to 19.1 to 85.5 mg Co/mg bw). Toxicity of cobalt sulfate is reported to be similar to the chloride with oral LD50s for rats ranging from 123 to 161 mg/kg bw (equivalent to 46.7 to 61.2 mg Co/kg bw). For the mouse, LD50 values were reported as 89.3 and 123 mg/kg for cobalt chloride and the cobalt sulfate, respectively, which are equivalent to 40.2 and 56.7 mg/kg bw when expressed as cobalt (ATSDR Sept 2001 Draft; see Appendix C).
Reference	:	

5.1.2 ACUTE INHALATION TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Exposure time	:	
LC50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** No acute inhalation studies have been located for cobalt chloride.
Reliability	:	
Reference	:	

5.1.3 ACUTE DERMAL TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	

LD50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** Increased proliferation of lymphatic cells was seen in rats, mice and guinea pigs dermally exposed to cobalt chloride, with LOAEL values ranging from 9.6 to 14.7 mg Co/kg/day. (Appendix C).
Reliability	:	
Reference	:	

5.2.1 SKIN IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** Dermatitis is a common result of dermal exposure to cobalt in humans and has been verified in a large number of studies. The dermatitis is probably caused by an allergic reaction to cobalt (Appendix C).
Reliability	:	
Reference	:	

5.2.2 EYE IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Dose	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	

Method detail	:
Result	:
Remark	:
Reliability	:
Reference	:

5.4 REPEATED DOSE TOXICITY

Type	:
Guideline/method	:
Species	:
Strain	:
Sex	:
Number of animals	:
Route of admin.	:
Exposure period	:
Frequency of treatment	:
Post exposure period	:
Doses	:
Control group	:
NOAEL	:
LOAEL	:
Other	:
Year	:
GLP	:
Test substance	:
Method	:
Method detail	:
Result	:
Remark	: **Supporting data for dissociation products:** **Acid:** Two repeated dose oral toxicity studies in rats have been conducted using tall oil fatty acids. In a 28-d dietary feeding study, the NOAEL was 15% when expressed in terms of total calories fed (Seppanen, 1969). Growth was significantly decreased at a feeding level of 30% of total calories. In a 90-d dietary feeding study, the NOEL was 5% in the diet or approximately 2,500 mg/kg/day (Fancher, 1969). The most sensitive effect was a reduction food consumption (but not body weight) at 10% in the diet. No effects on clinical signs or histopathology were reported at feeding levels up to 25% in the diet. See robust summaries in attached document prepared by the Pine Chemicals Association (Appendix E). **Metal:** Repeated oral dosing of rats for 150-210 days with cobalt chloride at 4 and 10 mg Co/kg indicated a LOAEL of 4 mg Co/kg, based upon increased organ weights. Eight weeks' oral exposure of rats to cobalt chloride hexahydrate indicated a LOAEL of 2.5 mg Co/kg (changes in hemoglobin and red blood cell count) and a NOAEL of 0.6 mg Co/kg. Other studies using repeated oral dosing for periods ranging from 12-16 days up to 7 months indicated LOAELs ranging from 0.5 to 30.2 mg Co/kg/day (as cobalt chloride) based upon observations such as reduced weight gain, increases in some organ weights (heart, liver and lungs); increased hematocrit, hemoglobin, and RBCs; renal tubular necrosis; and various changes on cardiac physiology (left ventricular hypertrophy, impaired ventricular function, and degeneration of myofibrils). Cardiac effects were observed in rats at LOAELs ranging from 8.4 to 12.4 mg Co/kg/day, for cobalt sulfate or cobalt chloride, with exposure periods of 3 weeks to 6 months (Appendix C).
Reliability	:
Reference	:

5.5 GENETIC TOXICITY 'IN VITRO'

Type	:	
Guideline/method	:	
System of testing	:	
Species	:	
Strain	:	
Test concentrations	:	
Cytotoxic concentr.	:	
Metabolic activation	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** Tall oil fatty acids tested negative in the Ames *Salmonella*/microsome plate test both with and without metabolic activation (Godek, 1983). Testing was conducted following OECD 471 with five different strains of *S. typhimurium* at doses up to 10,000 µg/plate. In the chromosomal aberration assay with Chinese hamster ovary cells (OECD 473), tall oil fatty acid was clastogenic with S9 mix at 20 ug/mL and without S9 mix at 156 ug/L; both concentrations were overtly toxic to the cells (Murie, 2001). See robust summaries in attached document prepared by the Pine Chemicals Association. (Appendix E). **Metal:** Cobalt compounds with a valence state of II, the form of cobalt released by dissociation of cobalt chloride, are reported to be generally non-mutagenic in *in vitro* bacterial assays, although weak positive responses have been observed under some conditions (Appendix C).
Reliability	:	
Reference	:	

5.6 GENETIC TOXICITY 'IN VIVO'

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Route of admin.	:	
Exposure period	:	
Doses	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Metal:** Cobalt compounds, including soluble salts, are observed to be clastogenic (cause chromosomal aberrations) in a range of mammalian assay systems. Increased micronucleus formation was observed following i.p. injection of 12.4 and 22.3 mg Co/kg (as cobalt chloride), but not after injection of 6.19 mg Co/kg (NOEL). In the mouse micronucleus test, a dose-

dependent increase in the frequency of micronucleated polychromatic erythrocytes was observed with i.p. exposure to cobalt chloride hexahydrate (Appendix C).

Reliability :
Reference :

5.8.2 DEVELOPMENTAL TOXICITY

Type :
Guideline/method :
Species :
Strain :
Sex :
Route of admin. :
Exposure period :
Frequency of treatment :
Duration of test :
Doses :
Control group :
NOAEL maternal tox. :
NOAEL teratogen. :
Other :
Other :
Other :
Year :
GLP :
Test substance :
Method :
Method detail :
Result :
Remark :

Supporting data for dissociation products:
Acid: The effects of tall oil fatty acids on rat developmental parameters have been studied in a two-generation feeding study (Tegeris, 1975). The study was generally consistent with OECD 416 except the initial treatment period for the parental generation was approximately three weeks prior to mating. Feeding levels were 0, 5, or 10% in the diet. Following weaning, the F_1 generation was fed the test article and mated at 100 days. The F_2 generation survived to weaning. Treatment did not affect the number of liveborn or stillborn F_1 litters and pups, or F_1 weaning weight. No treatment-related changes in fertility, viability, lactation, or gestation indices were measured. Clinical chemistry and pathological examinations also did not reveal treatment-related effects. It was concluded that tall oil fatty acid had no reproductive or developmental effects on rats at doses as high as 10% (approx. 5,000 mg/kg/day). See robust summary in attached document prepared by the Pine Chemicals Association (Appendix E).
Metal: In a developmental toxicity study with cobalt chloride exposure (5.4 or 21.8 mg Co/kg/day) in rats from gestation day 14 to lactation day 21, stunted pup growth was seen at all dose levels. However, maternal toxicity was observed in conjunction with effects on the offspring. This growth effect was considered to be a secondary or indirect effect rather than a direct effect of cobalt on the fetus. No teratogenic effects were observed. Another study in rats provided a NOAEL of 24.8 mg Co/kg/day for cobalt chloride exposure from gestation days 6-15. In a screening study, no effects were observed on fetal growth or survival in mice exposed to 81.7 mg Co/kg/day as cobalt chloride during gestation days 8-12 (Appendix C).

Reliability :
Reference :

5.8.3 TOXICITY TO REPRODUCTION

Type	:	
Guideline/method	:	
In vitro/in vivo	:	
Species	:	
Strain	:	
Sex	:	
Route of admin.	:	
Exposure period	:	
Frequency of treatment	:	
Duration of test	:	
Doses	:	
Control group	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	**Supporting data for dissociation products:** **Acid:** The effects of tall oil fatty acids on rat reproductive parameters have been studied in a two-generation feeding study (Tegeris, 1975). The study was generally consistent with OECD 416 except the initial treatment period for the parental generation was approximately three weeks prior to mating. Feeding levels were 0, 5, or 10% in the diet. Following weaning, the F_1 generation was fed the test article and mated at 100 days. The F_2 generation survived to weaning. Treatment did not affect the number of liveborn or stillborn F_1 litters and pups, or F_1 weaning weight. No treatment-related changes in fertility, viability, lactation, or gestation indices were measured. Clinical chemistry and pathological examinations also did not reveal treatment-related effects. It was concluded that tall oil fatty acid had no reproductive or developmental effects on rats at doses as high as 10% (approx. 5,000 mg/kg/day). See robust summary in attached document prepared by the Pine Chemicals Association (Appendix E). **Metal:** Male mice exposed to cobalt chloride hexahydrate in drinking water for 12-13 weeks demonstrated effects on testicular weight and sperm concentration at all dose levels (23 – 58.9 mg Co/kg bw). Rats exposed to 20 mg Co/kg bw (as cobalt chloride hexahydrate) through the diet showed degenerative and necrotic lesions in seminiferous tubles and testicular atrophy (Appendix C).
Reliability	:	
Reference	:	

6.0 OTHER INFORMATION

Supporting data for dissociation products:
Acid: A safety assessment of tall oil acid (a purified form of tall oil fatty acids) has been performed for use in cosmetic products by an Expert Panel (Expert Panel, 1989). Based on its review of available data for tall oil acid and its primary constituent (oleic acid), the Expert Panel concluded that tall oil acid is safe for use in cosmetics. The Expert Report includes a clinical assessment of safety for dermal exposure based on testing in human subjects. Several studies were conducted with liquid soaps containing 12% tall oil acid. These studies included a 4-week hand washing study with a diluted soap (final concentration of 3% tall oil acid) and two repeated dose patch studies with undiluted soap. None

of the subjects in these studies had positive reactions and the soap was found to be non-irritating and non-sensitizing.

Expert Panel. 1989. Final report on the safety assessment of tall oil acid. J. Amer. Coll. Toxicol. 8:769-776.

6.1 CARCINOGENICITY

Supporting data for dissociation products:
Metal: The US National Toxicology Program does not recognize cobalt as a human carcinogen, but IARC has classified cobalt and cobalt compounds as possibly carcinogenic to humans (Class 2B) based on sufficient evidence that cobalt metal powder and cobaltous oxide are carcinogenic in animals (Barceloux 1999, ATSDR Sept 2001 Draft). "No studies were located regarding carcinogenic effects in animals after oral exposure to stable [non-radioactive] cobalt." (ATSDR Sept 2001 Draft).

APPENDIX C

COBALT CHLORIDE ROBUST SUMMARIES

1. General Information

ID 7646-79-9

Date January 31, 2005

1.0 SUBSTANCE INFORMATION

Generic Name	:	Cobalt chloride
Chemical Name	:	Cobaltous chloride
CAS Registry No.	:	7646-79-9
Component CAS Nos.	:	
EINECS No.	:	
Structural Formula	:	$CoCl_2$
Molecular Weight	:	129.84
Synonyms and Tradenames	:	Cobalt(II) chloride; Cobalt dichloride
References	:	ATSDR, 2001. Draft Toxicological Profile for Cobalt, U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (ATSDR), September 2001. (This reference is subsequently listed in this document as ATSDR Sept 2001 Draft).

2.1 MELTING POINT

Type	:	
Guideline/method	:	
Value	:	735 °C
Decomposition	:	at °C
Sublimation	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	Decomposes at 400 °C on long heating in air
Reliability	:	2 (reliable with restrictions): Source is well established data compendium.
Reference	:	O'Neil, M.J., Smith, A., Heckelman, P.E., and J.R. Obenchain (eds.). 2002. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Ed. Merck & Co., Inc., Whitehouse Station, NJ

2.2 BOILING POINT

Type	:	
Guideline/method	:	
Value	:	1,049 °C
Decomposition	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	2 (reliable with restrictions): Source is well established data compendium.
Reference	:	O'Neil, M.J., Smith, A., Heckelman, P.E., and J.R. Obenchain (eds.). 2002. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Ed. Merck & Co., Inc., Whitehouse Station, NJ

2.3 DENSITY

Type	:	
Guideline/method	:	
Value	:	3.367 at 25 °C
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	2 (reliable with restrictions): Source is well established data compendium.
Reference	:	O'Neil, M.J., Smith, A., Heckelman, P.E., and J.R. Obenchain (eds.). 2002. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Ed. Merck & Co., Inc., Whitehouse Station, NJ

2.4 VAPOR PRESSURE

Type	:	
Guideline/method	:	
Value	:	hPa at °C
Decomposition	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

2.5 PARTITION COEFFICIENT

Type	:	
Guideline/method	:	
Partition coefficient	:	
Log Pow	:	at °C
pH value	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	Not applicable – metal dissociates (ionizes) in water
Reliability	:	
Reference	:	

2.6.1 SOLUBILITY IN WATER

Type	:	
Guideline/method	:	
Value	:	450 g/L at 7 °C
pH value	:	
concentration	:	at °C
Temperature effects	:	
Examine different pol.	:	
PKa	:	at °C
Description	:	
Stable	:	
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	544 g/L in ethanol; 86 g/L in acetone
Reliability	:	2 (reliable with restrictions): Source is well established data compendium
Reference	:	Weast. R.C. (ed.). 1988-1989. Handbook of Chemistry and Physics. 69th Ed. CRC Press Inc., Boca Raton, FL., p. B-86.

2.7 FLASH POINT

Type	:	
Guideline/method	:	
Value	:	°C
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

3.1.1 PHOTODEGRADATION

Type				
Guideline/method	:			
Light source	:			
Light spectrum	:			
Relative intensity	:	based on		
Spectrum of substance	:	lambda (max, >295nm)	:	
		epsilon (max)	:	
		epsilon (295)	:	
Conc. of substance	:		at	°C
DIRECT PHOTOLYSIS				
Halflife (t1/2)	:			
Degradation	:	% after		
Quantum yield	:			
INDIRECT PHOTOLYSIS				
Sensitizer	:			
Conc. of sensitizer	:			
Rate constant	:			
Degradation	:			
Deg. product	:			
Year	:			
GLP	:			
Test substance	:			
Deg. products CAS#	:			
Method	:			
Method detail	:			
Result	:			
Remark	:	Not applicable – metal does not degrade		
Reliability	:			
Reference	:			

3.2.1 MONITORING DATA

Type of measurement	:	
Media	:	
Concentration	:	
Substance measured	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

3.3.1 TRANSPORT (FUGACITY)

Type	:	
Media	:	
Air	:	% (Fugacity Model Level I)
Water	:	% (Fugacity Model Level I)
Soil	:	% (Fugacity Model Level I)
Biota	:	% (Fugacity Model Level II/III)
Soil	:	% (Fugacity Model Level II/III)
Year	:	
Test substance	:	
Method	:	

Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

3.5 BIODEGRADATION

Type	:	
Guideline/method	:	
Inoculum	:	
Concentration	:	related to related to
Contact time	:	
Degradation	:	(±) % after day(s)
Result	:	
Kinetic of test subst.	:	% (specify time and % degradation) % % % %
Control substance	:	
Kinetic	:	% %
Deg. product	:	
Year	:	
GLP	:	
Test substance	:	
Deg. products CAS#	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	Not applicable – the metal will not degrade
Reliability	:	
Reference	:	

3.7 BIOCONCENTRATION

Type	:	
Guideline/method	:	
Species	:	
Exposure period	:	at °C
Concentration	:	
BCF	:	
Elimination	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

4.1 ACUTE TOXICITY TO FISH

Type	:	Acute
Guideline/method	:	Flow-through, freshwater
Species	:	Rainbow trout (*Onchorhynchus mykiss*)
Exposure period	:	96 hr
NOEC	:	
LC0	:	
LC50	:	1.41 mg Co/L (95% C.I. = 0.57 – 3.47 mg Co/L)
LC100	:	
Other	:	LC20 = 0.53 mg Co/L (95% C.I. = 0.24 – 1.20 mg Co/L)
Other	:	Incipient lethal level for 50% mortality (time independent) = 0.35 mg Co/L
Other	:	144-hr LC50 = 0.52 mg Co/L (95% C.I. = 0.29 – 0.95 mg Co/L)
Limit test	:	
Analytical monitoring	:	Yes (results based on measured concentrations)
Year	:	1998
GLP	:	No
Test substance	:	Cobalt chloride dihydrate ($CoCl_2 \cdot 2H_20$)
Method	:	
Method detail	:	Tests were conducted with trout fry in water with an alkalinity and hardness of approximately 25 mg $CaCO_3$/L. Exposure concentrations ranged from 0.125 to 2.0 mg Co/L. Exposures were continued for up to 14 days, with mortality assessed every 2 hr for the first 48 hr, and every 6 h thereafter.
Result	:	The onset of mortality was slow (48 hr or greater), generally not reaching a plateau for 200 hr or more.
Remark	:	Study data indicate that the rainbow trout is highly sensitive to the toxic effects of cobalt. For comparison, reported 96-h LC50 values for other fish species include 22.0 mg Co/L for the fathead mninnow (*Pimephales promelas*), 333 mg Co/L for the carp (*Cyprinus carpio*), and 275 mg Co/L for the mummichog (*Fundulus heteroclitus*) (U.S. EPA, ECOTOX data base, 2003). Available data suggest that toxicity to fish is reduced with increasing hardness up to a hardness of approximately 400 mg $CaCO_3$/L (Diamond, J. et al., 1992. Aquat. Toxicol., 22:163-180).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study
Reference	:	Marr, J.C.A., J.A. Hansen, J.S. Meyer, D. Cacela, T. Podrabsky, J. Lipton, and H.L. Bergman. 1998. Toxicity of cobalt and copper to rainbow trout: application of a mechanistic model for predicting survival. Aquat. Toxicol., 43(4):225-238.

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type	:	Acute
Guideline/method	:	Static, freshwater
Species	:	*Daphnia magna* (water flea)
Exposure period	:	48 hr
NOEC	:	
EC0	:	
EC50	:	1.52 mg Co/L (95% C.I. = 1.01 - 2.28 mg Co/L)
EC100	:	
Other	:	24 hr LC50 = 2.11 mg Co/L (95% C.I. = 1.49 - 3.05 mg Co/L)
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	No
Year	:	1987
GLP	:	No

Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	American Public Health Association (APHA), 1976, Standard Methods for the Examination of Water and Wastewater.
Method detail	:	Tests were conducted in well water with a total hardness of 240 mg $CaCO_3$/L and a total alkalinity of 400 mg $CaCO_3$/L. Solutions were not renewed during the test. Daphnids were not fed during the test.
Result	:	
Remark	:	In an older study, the 48-hr LC50 for *Daphnia magna* has been reported as 5.5 mg Co/L (Cabejszek and Stasiak, 1960 as cited in the U.S. EPA ECOTOX database, 2003). The 48-hr LC50 for another daphnid, *Daphnia hyaline*, has been reported as 1.52 mg Co/L (Baudouin and Scoppa, 1974 as cited in the U.S. EPA ECOTOX database, 2003). Others have found 48-hr LC50 values for *Ceriodaphnia dubia* of 2.35, 4.60, and 4.20 mg Co/L for tests conducted with water hardness of 50, 200, and 400 mg $CaCO_3$/L, respectively (Diamond, J. et al., 1992. Aquat. Toxicol., 22:163-180).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study
Reference	:	Khangarot, B.S., P.K. Ray, and H. Chandra. 1987. *Daphnia magna* as a model to assess heavy metal toxicity: comparative assessment with mouse system. Acta. Hydrochim. Hydrobiol., 15(4): 427-432.

4.3 TOXICITY TO AQUATIC PLANTS (E.G., ALGAE)

Type	:	Algal growth assay
Guideline/method	:	Static, freshwater
Species	:	*Chlorella vulgaris* (green algae)
Endpoint	:	Population growth
Exposure period	:	96 hr
NOEC	:	
LOEC	:	
EC0	:	
EC10	:	
EC50	:	0.52 mg Co/L (95% C.I. = 0.48 – 0.56 mg Co/L)
Other	:	
Other	:	
Other	:	
Limit test	:	
Analytical monitoring	:	No
Year	:	1993
GLP	:	
Test substance	:	Cobalt chloride
Method	:	
Method detail	:	Tests conducted in modified Bristol's medium (pH 6.5) with a 16:8 day/night photoperiod (280 foot candles). Cultures were incubated at 19°C ± 1°C. Results were based on experiments run in triplicate.
Result	:	Growth was 63.8% and 28.4% of controls at concentrations of 0.32 and 1.00 mg Co/L, respectively.
Remark	:	Other aquatic plants are much less sensitive to cobalt. The reported 96-h EC50 for *Spirulina platensis* (blue-green algae) is 23.8 mg Co/L (Sharma et al., 1987 as cited in the U.S. EPA ECOTOX database, 2003). The 7-d IC50 for *Lemna minor* (duckweed) is 16.9 mg Co/L (Dirilgen and Inel, 1994 as cited in the U.S. EPA ECOTOX database, 2003).
Reliability	:	2 (reliable with restrictions); comparable to guideline study
Reference	:	Rachlin, J.W. and A. Grosso. 1993. The growth response of the green alga *Chlorella vulgaris* to combined divalent cation exposure. Arch. Environ. Contam. Toxicol., 24: 16-20.

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

In vitro/in vivo	:	
Type	:	
Guideline/method	:	
Species	:	
Number of animals	:	
Males	:	
Females	:	
Doses	:	
Males	:	
Females	:	
Vehicle	:	
Route of administration	:	
Exposure time	:	
Product type guidance	:	
Decision on results on acute tox. tests	:	
Adverse effects on prolonged exposure	:	
Half-lives	:	1st: 2nd: 3rd:
Toxic behavior	:	
Deg. product	:	
Deg. products CAS#	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	Absorption of cobalt in the digestive tract is influenced by the chemical form of the metal, with increasing solubility resulting in increasing absorption (ATSDR Sept 2001 Draft). Approximately 13-34% of cobalt chloride, a soluble form, is absorbed in the gut of rats, but absorption in the gut may be increased in iron deficient individuals. Following oral exposure, cobalt is eliminated primarily in feces and secondarily in urine. For the more soluble forms of cobalt, e.g., cobalt chloride, 70 – 80% of the administered dose is eliminated in the feces. For absorbed cobalt, elimination is rapid primarily in the urine (Barceloux, D.G. 1999. Cobalt. Clin. Tox. 37:201-206). Elimination is biphasic or triphasic. The terminal phase involves a very small residual level of cobalt and has a half-life in years (ATSDR Sept 2001 Draft).
Reliability	:	
Reference	:	

5.1.1 ACUTE ORAL TOXICITY

Type	:	Oral
Guideline/Method	:	Not specified
Species	:	Rat
Strain	:	Wistar
Sex	:	Male and female
Number of animals	:	5 per sex per dose level
Vehicle	:	Distilled water
Doses	:	50, 600, 720, 864, and 1137 mg/kg

LD50	:	766 mg/kg as compound (hexahydrate); 95% C.I. = 677 – 867 mg/kg) 190 mg/kg as cobalt
Year	:	1982
GLP	:	No
Test substance	:	Cobalt(II) chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	Single dose administered by gastric incubation
Method detail	:	Mortality assessed after a 10-d observation period.
Result	:	
Remark	:	Reported LD50s of cobalt chloride to rats range from 42.4 to 190 mg Co/kg bw (ATSDR Sept 2001 Draft). Toxicity of cobalt sulfate is reported to be similar to that of the chloride with oral LD50s for rats ranging from 123 to 161 Co/kg bw)(ATSDR Sept 2001 Draft). For the mouse, LD50 values are 89.3 and 123 mg Co/kg for cobalt chloride and cobalt sulfate (ATSDR Sept 2001 Draft).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Speijers, G.J.A., E.I. Krajnc, J.M. Berkvens, and M.J. van Logten. 1982. Acute oral toxicity of inorganic cobalt compounds in rats. Food Chem. Toxicol., 20:311-314.

5.1.2 ACUTE INHALATION TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Exposure time	:	
LC50	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	No acute toxicity studies have been located for this compound.
Reliability	:	
Reference	:	

5.1.3 ACUTE DERMAL TOXICITY

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
LD50	:	
Year	:	
GLP	:	
Test substance	:	

Method	:	
Method detail	:	
Result	:	
Remark	:	Increased proliferation of lymphatic cells was seen in rats, mice and guinea pigs dermally exposed to cobalt chloride in DMSO once per day for 3 consecutive days, with LOAEL values ranging from 9.6 to 14.7 mg Co/kg/day (Ikarashi, Y., et al., 1992. Toxicology, 76:283-292). Stimulation indices of 3 or greater (indicative of a significant response by the authors), were reported for mice exposed to 1, 2.5 or 5% $CoCl_2$ (equivalent to 10.8, 27, or 54.1 mg Co/kg/day), rats exposed to 2.5 or 5% $CoCl_2$ (equivalent to 9.6 or 19.2 mg Co/kg/day), and guinea pigs exposed to 5% $CoCl_2$ (equivalent to 14.7 mg Co/kg/day).
Reliability	:	
Reference	:	

5.2.1 SKIN IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	
Method detail	:	
Result	:	
Remark	:	Dermatitis is a common result of dermal exposure to cobalt in humans and has been verified in a large number of studies (ATSDR Sept 2001 Draft). The dermatitis is probably caused by an allergic reaction to cobalt.
Reliability	:	
Reference	:	

5.2.2 EYE IRRITATION

Type	:	
Guideline/method	:	
Species	:	
Strain	:	
Sex	:	
Concentration	:	
Dose	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
Classification	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	

Method detail	:	
Result	:	
Remark	:	
Reliability	:	
Reference	:	

5.4 REPEATED DOSE TOXICITY

Type	:	Repeated dose
Guideline/method	:	Oral
Species	:	Rat
Strain	:	Not specified
Sex	:	Male
Number of animals	:	30
Route of admin.	:	Oral via stomach tube
Exposure period	:	150 to 210 days
Frequency of treatment	:	Five days per week
Post exposure period	:	0 to 30 days
Doses	:	4 or 10 mg Co/kg
Control group	:	Yes
NOAEL	:	
LOAEL	:	4 mg Co/kg (organ weights increased)
Other	:	
Year	:	1959
GLP	:	No
Test substance	:	Cobalt chloride
Method	:	
Method detail	:	The erythrocyte count, hemoglobin and hematocrit determinations were performed at frequent intervals for animals receiving 10 mg Co/kg. At study termination, all rats were sacrificed, organs examined and weighed, and sections made histological examination.
Result	:	The average weights of kidneys, livers, and spleens of the cobalt-treated groups were slightly heavier than the controls. Cobalt exposure at 10 mg/kg produced significant polycythemia. Histological examination of the kidneys revealed necrosis of the linings of the tubules in rats treated with 10 mg Co/kg, but not in those of the 4 mg Co/kg group. The effects was reversible, however, as examination of kidneys of rats autopsied 30 days after cobalt administration was discontinued showed no necrosis and were normal compared to the kidneys from control rats.
Remark	:	Results are highly consistent with those reported by others. Repeated oral dosing of rats with cobalt chloride at levels ranging from 0.5 to 30.2 mg Co/kg/day (as cobalt chloride) for periods ranging from 12-16 days up to 7 months resulted in the following observations associated with LOAELs: reduced weight gain, increases in some organ weights (heart, liver and lungs); increased hematocrit, hemoglobin, and red blood cells; renal tubular necrosis; and various changes on cardiac physiology (left ventricular hypertrophy, impaired ventricular function, and degeneration of myofibrils) (ATSDR Sept 2001 Draft). Cardiac effects were observed in rats at LOAEL's ranging from 8.4 to 12.4 mg Co/kg/day, for cobalt sulfate or cobalt chloride, with exposure periods of 3 weeks to 6 months (ATSDR Sept 2001 Draft).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Murdock, H.R. 1959. Studies on the pharmacology of cobalt chloride. J. Amer. Pharm. Assoc., 48:140-142.
Type	:	Repeated dose

Guideline/method	:	Not specified
Species	:	Rat
Strain	:	Sprague-Dawley
Sex	:	Male
Number of animals	:	4
Route of admin.	:	Oral
Exposure period	:	8 weeks
Frequency of treatment	:	Daily
Post exposure period	:	None
Doses	:	2.5, 10, or 40 mg/kg (equivalent to 0.6, 2.5, or 10 mg Co/kg)
Control group	:	Yes
NOAEL	:	0.6 mg Co/kg
LOAEL	:	2.5 mg Co/kg (hemoglobin, red blood cell count)
Other	:	
Year	:	1947
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	
Method detail	:	Cobalt was administered orally in a gelatin capsule (mixed in equal part of wheat flour and powdered sugar). Blood counts and hemoglobin determinations were made at the start of the test and at two week intervals.
Result	:	Hemoglobin content and numbers of erythrocytes were increased in rats receiving either 2.5 or 10 mg Co/kg/day, but not in those receiving 0.6 mg Co/kg/day.
Remarks	:	Other researchers have reported similar results in long-term studies with rats although many study details are lacking in the published report (Krasovskii, G.N. and S.A. Fridlyand. 1971. Hyg. Sanit., 26:277-279). They found that oral doses of 0.5 and 2.5 mg Co/kg six days per week for seven months stimulated hemopoiesis and decreased immunological reactivity (reduced the phagocytic index). Daily doses of 0.5 mg Co/kg and greater also produced mild to moderate increases in conditioned flexes. However, daily doses of 0.05 mg Co/kg had no effects on the indices investigated. Others have also reported the neurotoxic and behavior effects of cobalt on rats after chronic dietary exposures (Nation, J.R. et al., 1983. Neurobehav. Toxicol. Teratol., 5:9-15).
Reliability	:	2 (reliable with restrictions): Documentation was incomplete; however, the results are highly consistent with others in the scientific literature.
Reference	:	Stanley, A.J., H.C. Hopps, and A.M. Shideler. 1947. Cobalt polycythemia. II. Relative effects of oral and subcutaneous administration of cobaltous chloride. Proc. Soc. Exp. Biol. Med., 66:19-20.

5.5 GENETIC TOXICITY - MUTAGENICITY

Type	:	Mutagenicity
Guideline/method	:	Ames Assay
System of testing	:	Bacteria *in vitro*
Species	:	*Salmonella typhimurium* LT2
Strains	:	TA100
Test concentrations	:	10^{-4} to 10^{-1} M
Cytotoxic concentr.	:	10^{-2} M
Metabolic activation	:	No
Year	:	1981
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	Ames, B.N., J. McCann, and E. Yamasaki. 1975. Mutat. Res., 31:347-364.
Method detail	:	

Result	:	Negative both above and below the cytotoxic concentration
Remark	:	Cobalt compounds with a valence state of II, the form of cobalt released by dissociation of cobalt chloride, are generally nonmutagenic in *in vitro* bacterial assays (ATSDR Sept 2001 Draft). For example, cobalt chloride was not mutagenic in plate incorporation and fluctuation assays with *Salmonella* TA strains or a *Escherichia coli* WP2 strain (Arlauskas, A., et al., 1985. Environ. Res., 36:379-388). However, a weak positive mutagenic response has been found in the rec assay with *Bacillus subtilis* at a concentration of 0.05 M (Kanematsu, N. et al., 1980. Mutat. Res., 77:109-116). A very weak positive response has also been found in Chinese hamster V79 cells, but only at a highly cytotoxic concentration (Miyaki, M. et al. 1979. Mutat. Res., 68: 259-263).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Tso, W-W. and W-P Fung. 1981. Mutagenicity of metallic cations. Toxicolog. Lett., 8:195-200.

Type	:	Mutagenicity
Guideline/method	:	Ames Assay
System of testing	:	Bacteria *in vitro*
Species	:	*Salmonella typhimurium* LT2
Strains	:	TA98, TA100, TA1537, and TA2637
Test concentrations	:	0.1 to 1,000 μM/plate
Cytotoxic conc.	:	Not specified
Metabolic activation	:	No
Year	:	1986
GLP	:	No
Test substance	:	Cobalt chloride
Method	:	Ames, B.N., J. McCann, and E. Yamasaki. 1975. Mutat. Res., 31:347-364.
Method detail	:	A modified Tris-HCl minimal medium with low phosphate content was used to prevent formation of insoluble metal phosphates in the test system.
Result	:	Negative
Remark	:	Although cobalt chloride alone did not produce mutants in this test system, it was mutagenic when it was added as a mixture with one of several heteroaromatic compounds (e.g., 4-aminoquinoline, 9-aminoacridine). The enhanced mutagenicity was attributed by the authors to the formation of weak to moderate complexes between these chemicals and the Co(II) cation, which may have enhanced transmembrane permeation or intercellular binding.
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Ogawa, H.I., K. Sakata, T. Inouye, S. Jyosui, Y. Niyitani, K. Kamimoto, M. Morishita, S. Tsuruta, and Y. Kato. 1986. Combined mutagenicity of cobalt(II) salt and heteroaromatic compounds in *Salmonella typhimurium*. Mutat. Res., 172: 97-104.

5.6 GENETIC TOXICITY - CLASTOGENICITY

Type	:	Chromosomal aberrations in bone marrow cells
Guideline/method	:	*In vivo*
Species	:	Mouse (*Mus musculus*)
Strain	:	Swiss albino
Sex	:	Male
Route of admin.	:	Oral (single dose)
Exposure period	:	6, 12, 18, or 24 hr.
Dose	:	20, 40 , or 80 mg/kg b.w.
Year	:	1991
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	Preston, R.J. et al., 1987. Mutat. Res., 189:157.
Method detail	:	Test compound was administered orally to five animals per dose group. Mice were 6-8 weeks old at that time. Colchicine (0.04%) was injected i.p. at 90 min prior to sacrifice. Bone marrow cells were removed form femurs by flushing with 0.8% sodium citrate. From each animal, 50 well-scattered metaphase plate were scored for chromosomal aberrations. Abnormalities were scored separately as total aberrations (with and without gaps) and as breaks per cell.
Result	:	Administration of cobalt chloride produced a concentration-dependent increase in total chromosomal aberrations.
Remark	:	Cobalt compounds, including soluble salts, are observed to be clastogenic (cause chromosomal aberrations) in a range of mammalian assay systems. For example, increased micronucleus formation was observed following i.p. injection of 12.4 and 22.3 mg Co/kg (as cobalt chloride), but not after injection of 6.19 mg Co/kg (NOEL) (ATSDR Sept 2001 Draft). There is evidence that soluble cobalt(II) cations exert a genotoxic activity in vitro and in vivo in experimental systems, but evidence in humans is lacking (Lison, D. et al., 2001. Occup. Environ. Med., 58: 619-625).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Palit, S., A. Sharma, and G. Talukder. 1991. Chromosomal aberrations induced by cobaltous chloride in mice in vivo. Biol. Trace Elem. Res., 29:139-145.

Type	:	Micronucleus Test
Guideline/method	:	In vivo
Species	:	Mouse
Strain	:	BALB/c AnNCRj
Sex	:	Male
Route of admin.	:	Intraperitoneally
Exposure period	:	30 hr
Doses	:	25, 50, or 90 mg Co/kg b.w.
Year	:	1993
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	Von Ledbur, M. and W. Schmid. 1973. Mutat. Res., 19:109-117.
Method detail	:	Mice were injected once ip and sacrificed after 30 hr. Bone marrow smears were prepared and stained. The incidence of micronucleated polychromatic erythrocytes (MPCE) was determined in 1,000 cells. In addition, the ratio of polychromatic erythrocytes (P) to normochromatic erythrocytes (N) was determined in 2,000 erythrocytes.
Result	:	Treatment with cobalt induced a dose-dependent increase in the frequency of MPCE. The P/N ratio was significantly reduced ($P<0.05$) in mice dosed at 90 mg/kg b.w.

Remark	:	This study also included an *in vitro* micronucleus test with mouse bone marrow cells, both with and without metabolic activation with an S9 fraction. In contrast to the *in vivo* test, the *in vitro* test did not produce any significant changes in frequency of MPCE or the P/N ratio at dose levels of cobalt chloride hexahydrate up to 50 mg/L in the cell suspension.
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Suzuki, Y., H. Shimizu, Y. Nagae, M. Fukumoto, H. Okonogi, and M. Kadokura. 1993. Micronucleus test and erythropoiesis: effect of cobalt on the induction of micronuclei by mutagens. Environ. Mol. Mutagen., 22:101-106.
Type	:	DNA damage in isolated human lymphocytes
Guideline/method	:	Alkaline Comet Assay (*in vitro*)
Species	:	Human
Strain	:	
Sex	:	Female
Route of admin.	:	In vitro
Exposure period	:	15 min
Doses	:	0.3, 0.6, 1.2, 1.5, 2.0, 2.5, 3.0, and 6.0 mg Co/L
Year	:	1998
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	The alkaline comet assay performed using a modification of the method of Singh et al. 1988. Exp. Cell. Res., 175:184-191.
Method detail	:	Tests were conducted on lymphocytes taken from two healthy female donors. Cells were for 15 min exposed after 24 of stimulation by phytohaemagglutinin. After treatment, the cells were centrifuged for 10 min at 400 g. The supernatant was removed and the cell pellet was resuspended and processed for the alkaline comet assay (single cell electrophoresis assay). Fifty or 100 randomly selected slides were analyzed, with tail length, tail DNA, and tail movement recorded.
Result	:	There was considerable interexperimental and interdonor variability in data; however, at the highest dose level (6.0 mg Co/L) there was a statistically significant increase in tail movement in all experiments, indicating DNA damage (single strand breaks and alkali labile sites). Tail movement was also increased at lower doses, but did not show a clear dose-dependent trend.
Remark	:	Using human lymphocytes and macrophages ($P388D_1$ cells), an increase in sister chromatid exchanges (SCE) after exposure to cobalt chloride at 10^{-4} to 10^{-5} M has been also demonstrated (Andersen, O. 1983. Environ. Health Perspect., 47: 239-253). Others have also found that cobalt chloride increases DNA strand breaks in human diploid fibroblasts and Chinese hamster ovary cells after *in vitro* exposures, although only when determined by alkaline sediment sucrose velocity sedimentation and not when measured by nucleoid sedimentation or nick translation assays (Hamilton-Koch, W. et al., 1986. Chem.-Biol. Interactions, 59:17-28).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	De Beck, M., D. Lison, and M. Kirsch-Volders. 1998. Evaluation of the in vitro direct and indirect genotoxic effects of cobalt compounds using the alkaline comet assay. Influence of interdonor and interexperimental variability. Carcinogenesis, 19:2021-2029.

5.8.2 DEVELOPMENTAL TOXICITY

Type	:	Developmental toxicity
Guideline/method	:	Not specified
Species	:	Rat
Strain	:	Wistar
Sex	:	Female
Route of admin.	:	Gastric intubation
Exposure period	:	Gestation day 14 through 21 days of lactation
Frequency of treatment	:	Daily
Duration of test	:	Through lactation day 21
Doses	:	12, 24, and 48 mg/kg b.w. (equivalent to 5.4, 10.8, or 21.8 mg Co/kg b.w.)
Control group	:	Yes
NOAEL maternal tox.	:	Not determined (no maternal data reported)
NOAEL teratogen.	:	Malformations not observed
Other	:	
Other	:	
Other	:	
Year	:	1985
GLP	:	No
Test substance	:	Cobalt chloride
Method	:	
Method detail	:	Cobalt chloride was administered to three groups of 15 pregnant rats from gestation day 14 through the 21st day of lactation. Pups were weighed and examined for signs of toxicity on days 1, 4, and 21 of lactation, and were sacrificed on day 21. Macroscopic examinations were made of the heart, lungs, spleen, liver, and kidneys following sacrifice. Clinical chemistry parameters were also measured.
Result	:	There was significant mortality of pups in the highest dose group and fewer litters produced at all dose levels. In addition, pups showed stunted growth (weight and length) at all dose levels. Relative weights of the liver (males and females) and spleen (females only) were reduced by cobalt exposure, but did not show a dose-related trend. Blood analysis and clinical chemistry showed no treatment related differences. No external malformations were observed in pups. Data from previous studies by the authors suggests that the upper two doses levels were maternally toxic, therefore, the results observed may have been indirectly due, at least in part, to effects on the mothers, rather than direct effects on the fetuses.
Remark	:	
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Domingo, J.L., J.L. Paternain, J.M. Llobet, and J. Corbella. 1985. Effects of cobalt on postnatal development and late gestation in rats upon oral administration. Rev. Esp. Fisiol., 41:293-298.

Type	:	Teratogenicity
Guideline/method	:	Not specified
Species	:	Rat
Strain	:	Sprague-Dawley
Sex	:	Female
Route of admin.	:	Oral gavage
Exposure period	:	Day 6 to 15 of gestation
Frequency of treatment	:	Daily
Duration of test	:	To day 20 of gestation
Doses	:	25, 50, or 100 mg/kg (equivalent to 6.2, 12.4, and 24.8 mg Co/kg b.w.)
Control group	:	Yes

NOAEL maternal tox.	:	Not determined (effects on weight gain seen at lowest dose)
NOAEL teratogen.	:	24.8 mg Co/kg b.w.
Other	:	NOAEL for maternal hematology was 12.4 mg Co/kg b.w.
Other	:	
Other	:	
Year	:	1998
GLP	:	
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	
Method detail	:	Pregnant females (20 per group) were dosed daily with cobalt chloride hexahydrate in distilled water during gestation days 6 to 15. Maternal body weights were recorded on days 0, 6, 9, 12, 16, and 19 of gestation. Individual food consumption was recorded for the following intervals: days 0-6, 6-9, 9-12, 12-16 and 16-19. Detailed physical examinations for signs of toxicity were performed at the same time that weights were recorded. On day 20 of gestation, dams were weighed, then sacrificed. Blood samples were collected for hematological analyses. After exsanguinations, the uterine horns were opened, examinations made and the following recorded: number of corpora lutea, total implantations, number of live and dead fetuses number of resorptions, average fetus body weight, number of stunted fetuses, fetal body length, and fetal tail length. Fetuses were also fixed, stained and examined for skeletal abnormalities.
Result	:	Maternal effects included significant reductions in weight gain and food consumption, particularly at the 24.8 mg Co/kg dose level, although effects on weight gain were found at all dose levels. Hematological parameters (e.g., hematocrit, hemoglobin content) were significantly increased in the highest dose group. No treatment-related changes were observed in the number of corpora lutea, total implants, resorptions, number of live and dead fetuses per litter, fetal size parameters, or fetal sex distribution data. Increased incidences of stunted fetuses per litter (those under two-thirds of the average fetus body weight) were seen in the two highest dose groups; however, the increases were not statistically significant. Examination of fetuses for gross external abnormalities, skeletal malformations, and ossification variations produced negative findings, indicating that cobalt doses as high as 24.8 mg Co/kg do not produce teratogenicity or significant fetotoxicity in the rat.
Remark	:	A lack of teratogenicity in the golden hamster has also been reported (Ferm, V.H. 1972. Adv. Teratol., 6:51-75.
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Paternain, J.L., J.L. Domingo, and J. Corbella. 1988. Developmental toxicity of cobalt in the rat. J. Toxicol. Environ. Health, 24:193-200.

Type	:	Developmental toxicity
Guideline/method	:	Chernoff/Kavlock developmental toxicity screen
Species	:	Mouse
Strain	:	ICR/SIM
Sex	:	Female
Route of admin.	:	Oral intubation
Exposure period	:	Gestation days 8 through 12
Frequency of treatment	:	Daily
Duration of test	:	Through postnatal day 3
Dose	:	180 mg/kg/day (equivalent to 81.7 mg Co/kg)
Control group	:	Yes
NOAEL maternal tox.	:	Not determined
NOAEL teratogen.	:	180 mg/kg/day (equivalent to 81.7 mg Co/kg)
Other	:	

Other	:	
Other	:	
Year	:	1986
GLP	:	
Test substance	:	Cobalt chloride
Method	:	Chernoff, N. and R.J. Kavlock. 1982. J. Toxicol. Environ. Health, 10:541-550.
Method detail	:	The screening test was carried out with a single minimally dose that was expected to result in significant maternal weight reduction, up to 10% mortality, or other clinical sings of overt toxicity. Treatment was by oral intubation on days 8 through 12 of gestation. Mice were allowed to deliver, and neonates examined, counted, and weighed on the day of birth (day 1) and day 3. Dead neonates were recovered from the nest and examined for abnormalities.
Result	:	The average maternal weight gain was significantly affected by cobalt treatment as desired in the protocol. Despite this, there was no effect of cobalt on litter size, percent survival of neonates on days 1-3, or average neonatal weight.
Remark	:	Results are in agreement with those seen in the rat, although another researcher has reported that injections of cobalt chloride to pregnant mice can lead to interference of skeletal ossification in fetuses (Wide, M. 1984. Environ. Res., 33:47-53).
Reliability	:	2 (Reliable with restrictions): comparable to guideline study with adequate documentation.
Reference	:	Seidenberg, J.M. D.G. Anderson, and R.A. Becker. 1986. Validation of an in vivo developmental toxicity screen in the mouse. Teratog. Carcinog. Mutagen., 6:361-374.

5.8.3 TOXICITY TO REPRODUCTION

Type	:	Male reproduction
Guideline/method	:	Not specified
In vitro/in vivo	:	In vivo
Species	:	Mouse
Strain	:	CD-1
Sex	:	Male
Route of admin.	:	Drinking water
Exposure period	:	12 weeks (dose-response study); 13 weeks (time course study)
Frequency of treatment	:	Continuous
Duration of test	:	12 weeks (dose-response study); 33 weeks (time course study)
Doses	:	10, 200, or 400 ppm in the dose-response study (equivalent to a daily intake of 23.0, 42.0, or 72.1 mg Co/kg b.w.); 400 ppm in the time course study (equivalent to a daily intake of 58.9 mg Co/kg b.w.)
Control group	:	Yes
Year	:	1988
GLP	:	No
Test substance	:	Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method	:	
Method detail	:	In the dose-response study, males (5 per dose) were evaluated after 12 weeks of exposure for testicular weight, epididymal sperm concentration, sperm motility, sperm fertilizing ability (fertility), prostatic weight, seminal vesicle weight, and serum levels of testosterone. In the time course study, males (5 per dose and time point) were evaluated after 7, 9, 11, or 13 weeks of exposure for most of these same parameters. In addition, fertility of the males was evaluated at regular intervals up to 20 weeks after cessation of cobalt treatment in the drinking water.
Result	:	Cobalt exposure affected male reproductive parameters in a time- and

dose-dependent manner. There was a significant decrease in testicular weight and epididymal sperm concentration after 11-13 weeks of exposure at all dose levels. Sperm motility and fertility were significantly depressed in the highest exposure groups. After cessation of exposure, some recovery was seen in fertility over time; however, indices remained significantly depressed through study termination (20 weeks after cessation). Parallel studies with acute cobalt chloride exposures (i.p injections of 200 μmoles/kg for 3 consecutive days) did not result in significant changes in male reproductive parameters, although transient affects on fertility were observed.

Remark : Histopathology studies of testes from mice treated with the same general exposure regimen as in this study (i.e., 400 ppm in drinking water for 13 weeks) showed a reproducible, sequential pattern of seminiferous tubule degeneration (Anderson, M.B. et al., 1992. Reprod. Toxicol., 6:41-50). Results of this study are highly consistent with others in which testicular degeneration and atrophy have been reported in rats exposed to 13.2 to 30.2 mg Co/kg/day as cobalt chloride for 2-3 months in the diet or drinking water (ATSDR Sept 2001 Draft).

Reliability : 2 (Reliable with restrictions): comparable to guideline study with adequate documentation.

Reference : Pedigo, N.G., W.J. George, and M.B. Anderson. 1988. Effects of acute and chronic exposure to cobalt on male reproduction in mice. Reprod. Toxicol., 2:45-53.

Type : Male reproduction
Guideline/method : Not specified
In vitro/in vivo : In vivo
Species : Rat
Strain : Sprague-Dawley
Sex : Male
Route of admin. : Diet
Exposure period : 98 d
Frequency of treatment : Continuous in diet
Duration of test : Up to 98 d
Doses : 265 ppm in diet (equivalent to 20 mg Co/kg b.w. at test initiation)
Control group : Yes
Year : 1985
GLP : No
Test substance : Cobalt chloride hexahydrate ($CoCl_2 \cdot 6H_20$)
Method :
Method detail : Three rats from the control and treatment groups were sacrificed on days 1, 2, 7, 14, 21, 28, 35, 42, 56, 63, 70, 84, and 98. Tissue specimens from the testes, cauda epididymus, and seminal vesicles were fixed and later examined.

Result : Dietary cobalt exposure induced consistent degenerative and necrotic lesions in the seminiferous tubules of rats. Cyanosis and engorgement of testicular vasculature on day 35 and thereafter was followed on day 70 by degenerative and necrotic changes in the germinal epithelium and Sertoli cells. Findings indicate that cobalt readily crosses the blood-testes barrier.

Remark : Results are consistent with those of Nation et al. (1983), who found significant testicular atrophy in rats exposed chronically to 20 mg Co/kg in the diet (Nation, J.R. et al., 1983. Neurobehav. Toxicol. Teratol., 5:9-15).

Reliability : 2 (Reliable with restrictions): comparable to guideline study with adequate documentation.

Reference : Corrier, D.E., H.H. Mollenhauer, D.E. Clark, M.F. Hare, and M.H. Elissalde. 1985. Testicular degeneration and necrosis induced by dietary cobalt. Vet. Pathol., 22:610-616.

6.0 OTHER INFORMATION

6.1 CARCINOGENICITY

The US National Toxicology Program does not recognize cobalt as a human carcinogen, but IARC has classified cobalt and cobalt compounds as possibly carcinogenic to humans (Class 2B) based on sufficient evidence that cobalt metal powder and cobaltous oxide are carcinogenic in animals (Barceloux 1999, ATSDR Sept 2001 Draft). "No studies were located regarding carcinogenic effects in animals after oral exposure to stable [non-radioactive] cobalt." (ATSDR Sept 2001 Draft).

APPENDIX D

STEARIC ACID ROBUST SUMMARIES

APPENDIX E

FATTY ACIDS, TALL OIL ROBUST SUMMARIES